

Hospital Costs Associated With Laparoscopic and Open Inguinal Herniorrhaphy

Fernando Spencer Netto, MD, PhD, Fayez Quereshy, MD, MBA, Bruna G. Camilotti, Kristen Pitzul, BScH, MSc, Josephine Kwong, BScH, MPA, Timothy Jackson, MD, MPH, Todd Penner, MD, Allan Okrainec, MD, MHPE

ABSTRACT

Purpose: The purpose of this study was to compare the total hospital costs associated with elective laparoscopic and open inguinal herniorrhaphy.

Methods: A prospectively maintained database was used to identify patients who underwent elective inguinal herniorrhaphy from April 2009 to March 2011. A retrospective review of electronic patient records was performed along with a standardized case-costing analysis using data from the Ontario Case Costing Initiative. The main outcomes were operating room (OR) and total hospital costs.

Results: Two hundred eleven patients underwent elective unilateral inguinal herniorrhaphy (117 open and 94 laparoscopic), and 33 patients underwent elective bilateral inguinal herniorrhaphy (9 open and 24 laparoscopic). OR and total hospital costs for open unilateral inguinal hernia repair were significantly lower than for the laparoscopic approach (median total cost, \$3207.15 vs \$3723.66; $P < .001$). OR and total hospital costs for repair of elective bilateral inguinal hernias were similar between the open and laparoscopic approaches (median total cost, \$4574.02 vs \$4662.89; $P = .827$).

Conclusions: In the setting of a Canadian academic hospital, when considering the repair of an elective unilateral inguinal hernia, the OR and total hospital costs of open surgery were significantly lower than for the laparoscopic techniques. There was no statistical difference between OR and total hospital costs when comparing open surgery and laparoscopic techniques for the repair of bilateral inguinal hernias. Given the perioperative benefits of laparoscopy, further studies incorporating hernia-specific outcomes are necessary to determine the cost-effective-

ness of each approach and to define the optimal treatment strategy.

Key Words: Hospital costs, Inguinal herniorrhaphy, Laparoscopic inguinal herniorrhaphy, Open inguinal herniorrhaphy.

INTRODUCTION

Inguinal herniorrhaphy is one of the most common elective procedures performed worldwide. In the United States, an estimated 800,000 inguinal hernia repairs are performed each year, accounting for 10% to 15% of all surgical procedures.¹ However, there continues to remain controversy surrounding the optimal surgical management of this condition. Several studies have validated the clinical utility of laparoscopic inguinal herniorrhaphy and have demonstrated comparable short-term safety and long-term efficacy relative to the open approach.^{2,3}

Given increasing fiscal constraints, procedural cost-effectiveness has become an important metric in evaluating surgical procedures. Although several studies have demonstrated higher costs associated with laparoscopic inguinal herniorrhaphy,⁴⁻⁶ others have successfully reported cost-containment strategies in laparoscopic surgery.⁷ Given that elective inguinal hernia repairs are most often ambulatory procedures, the direct operating room (OR) expense predominates as the driving factor in the total cost of care. Therefore, the objective of this study was to compare the OR and total hospital costs associated with laparoscopic versus open inguinal herniorrhaphy performed at a publicly funded, tertiary academic institution.

MATERIALS AND METHODS

Using a prospectively maintained database, all patients undergoing elective open or laparoscopic inguinal hernia repair between April 2009 and March 2011 at the Toronto Western Hospital, University Health Network, were identified. Open inguinal herniorrhaphy was performed using a standardized Lichtenstein repair with either a polypropylene or a polyester mesh. A retrospective review of electronic patient records was performed, along with a

Universidade do Oeste do Parana, Cascavel, Brazil (Dr Spencer Netto); Division of General Surgery, University Health Network, Toronto, Ontario, Canada (Pitzul, Kwong, Drs Quereshy, Jackson, Penner, and Okrainec); Department of Surgery, University of Toronto, Toronto, Ontario, Canada (Drs Quereshy, Jackson, Penner, and Okrainec); Universidade Regional de Blumenau, Blumenau, Brazil (Dr Camilotti).

Address correspondence to: Fernando Spencer Netto, MD, PhD, R. Dom Pedro II, 2099/1302, Cascavel, PR, Brazil, CEP: 85812-120, E-mail: fspencernetto@gmail.com
DOI: 10.4293/JSLS.2014.00217

© 2014 by JSLS, Journal of the Society of Laparoendoscopic Surgeons. Published by the Society of Laparoendoscopic Surgeons, Inc.

standardized case-costing analysis using data from the Ontario Case Costing Initiative.

Laparoscopic mesh repair varied by surgeon preference between a standardized transabdominal preperitoneal (TAPP) and a total extraperitoneal (TEP) approach. As part of a local cost-awareness strategy, permanent trocars are preferentially used. Laparoscopic balloons to dissect the preperitoneal space were rarely used.

Primary outcome variables included OR and total hospital costs. Monetary values are shown in Canadian dollars and were converted to 2012 values using Consumer Price Index inflationary adjustments. Secondary outcomes included perioperative complications, 30-day hospital readmission, and 30-day emergency department visits. Short-term perioperative complications included early recurrence, surgical site infection, seroma and hematoma formation, and urinary retention.

Statistical analysis was conducted using SPSS version 21 (SPSS, Inc, Chicago, Illinois). Patient data were evaluated using an intention-to-treat approach. Continuous variables are expressed as means or medians and were compared using *t* tests, analysis of variance, or Mann-Whitney *U* tests as appropriate. Categorical variables are expressed as proportions and were compared using either χ^2 or Fisher exact tests. A 2-sided *P* value < .05 was considered statistically significant.

Costing Analysis

The University Health Network Case Costing Department (CCD) is responsible for capturing costs ascribed to each patient's hospital visit. The University Health Network subsequently reports this information at regular intervals to ensure fiscal responsibility and fiduciary control. The total cost of care is recorded under the patient's unique medical record number and a specific hospital visit number. The total cost per patient visit (from preadmission to discharge) is an aggregate of individual departmental costs; for the purposes of this study, departmental costing centers were grouped as appropriate and termed "hospital departments."

Specific visit numbers relating to patients undergoing elective inguinal herniorrhaphy were used to retrieve costing information from the CCD. The estimate of cost was performed using a "bottom-up" approach, which identifies all of the resources directly used for a given intervention.⁸ The CCD uses a microeconomic method of costing. As such, total direct cost is calculated on the basis of the consumption of resources, including supplies, med-

ications, investigations, food, and lodging expense. Each OR has a computerized dispensing cabinet that itemizes supplies used during each case and allocates cost to a specific patient procedure (Pyxis ProcedureStation System; Cardinal Health, Dublin, Ohio). All pharmaceuticals throughout the hospital are dispensed by a similar system (Pyxis MedStation System; Cardinal Health). These costs are detailed in the CCD reports as "direct costs."

Personnel cost data were based on budgetary statements provided by individual hospital departments to the CCD. Personnel cost includes the wages (compensation and benefits) of the nursing, paramedical, and administrative staffs. These totals were calculated using a "top-down" approach by dividing total costs by the number of patients admitted on any given day.⁹ These costs are subsequently reported in the CCD figures as the "indirect costs" associated with specific hospital visits. Additional overhead expenses, such as heating costs, are derived by dividing total costs by ward square footage and the number of admitted patients. Equipment (including maintenance), facilities, and other global expenses (including information technology infrastructure) were included in departmental budgets.

Physician fees are separately reimbursed by the Ontario Ministry of Health and were not recorded in this study. Furthermore, postdischarge care, follow-up, readmission, and potential loss of income were not included in this analysis. All costs were adjusted for inflation to 2012 Canadian dollars according to the Bank of Canada's inflation calculator.

RESULTS

During the study period, 244 patients underwent elective inguinal hernia repair. One hundred twenty-six patients (51.6%) underwent open inguinal herniorrhaphy, while 118 (48.4%) underwent laparoscopic repair. Among the laparoscopic cases, 94 patients (79.7%) underwent TAPP repair, while 24 (20.3%) were treated using the TEP technique.

The demographic profiles of the 2 study cohorts are shown in **Table 1**. Patients undergoing laparoscopic hernia repair were younger (mean age, 55 vs 66 years; *P* < .001) and had lower American Society of Anesthesiologists classes (*P* < .001). A significantly higher proportion of patients undergoing open surgical repair had histories of abdominal surgery (67.5% vs 46.6%, *P* < .001). Bilateral inguinal hernia repair was preferentially performed using a laparoscopic approach (72.7% vs 27.3%, *P* = .002), and all hernias diagnosed as bilateral had both sides operated during the same procedure.

Table 1.
Patient Demographics

Variable	Open	Laparoscopic	P
	n = 126 (51.6)	n = 118 (48.4)	
Age, mean, y	66	55	<.001
BMI, mean, kg/m ²	27	27	.992
Men	119 (94.4)	111 (94.1)	.900
ASA class			
I	11 (8.7)	37 (31.4)	<.001
II	39 (31.0)	52 (44.1)	
III	68 (54.0)	26 (22)	
IV	8 (6.3)	3 (2.5)	
Previous abdominal surgery, No. (%)	85 (67.5)	55 (46.6)	.001
Laterality, No. (%)			
Unilateral	117 (92.9)	94 (79.7)	.002
Bilateral	9 (7.1)	24 (20.3)	
Direct/indirect, No. (%)			
Direct	42 (33.3)	50 (42.4)	.068
Indirect	64 (50.8)	53 (44.9)	
Pantaloon	7 (5.6)	10 (8.5)	
Not specified	13 (10.3)	5 (4.2)	
Recurrent, No. (%)	12 (9.5)	8 (6.8)	.186

ASA, American Society of Anesthesiologists; BMI, body mass index.

The perioperative outcomes for the 2 groups are shown in **Table 2**. All laparoscopic inguinal herniorrhaphies were performed under general anesthesia, compared with 42.9% of open cases. Twenty-three patients undergoing open inguinal herniorrhaphy required postoperative admission, compared with 2 patients in the laparoscopic cohort ($P = .025$). There was no difference in the incidence of early recurrence or early postoperative complications. One case was converted from laparoscopic (TAPP technique) to open repair because of significant small bowel adhesions. During the study period, there were no deaths or major complications identified in either group. Patients in the laparoscopic group had a longer median OR time of 101 minutes compared with 84 minutes for open repairs ($P < .001$).

Total hospital costs (from preadmission to discharge) for open unilateral inguinal herniorrhaphy were significantly lower than for the laparoscopic approach (median total cost, \$3207.15 and \$3723.66, respectively; $P < .001$). This difference in total costs was driven primarily by the OR costs associated with the laparoscopic approach (median

OR cost, \$2399.49 and \$3092.03, respectively; $P < .001$) (**Table 3**). However, OR and total hospital costs for repair of elective bilateral inguinal hernias were similar between the open and laparoscopic approaches (median total hospital cost, \$4574.02 vs \$4662.89; $P = .827$) (**Table 4**).

When comparing unilateral and bilateral hernia repair within the laparoscopic cohort, there was no statistical difference in the cost (either OR or total episode of care) between the TAPP and TEP techniques. Further to the operative approach, the use of general anesthesia was associated with an increased cost compared with other types of anesthesia (local or regional) ($P < .0001$).

DISCUSSION

In this study, we systematically reviewed the OR and total hospital costs involved with the treatment of inguinal hernias and, specifically, compared the costs associated with an open versus a laparoscopic approach. Our results demonstrate that OR and total hospital costs for open unilateral

Table 2.
Intra- and Postoperative Outcomes

Variable	Open n = 126 (51.6%)	Laparoscopic n = 118 (48.4%)	P (ANOVA)
Anesthesia, No. (%)			
General	54 (42.9)	118 (100)	.000
Local/regional	70 (55.6)	0 (0)	
Spine	2 (1.6)	0 (0)	
Type of mesh, No. (%)			
Polypropylene	116 (92.1)	57 (48.3)	.833
Polyester	7 (5.6)	60 (50.8)	
No mesh	1 (0.8)	0 (0)	
Not specified	2 (1.6)	1 (0.8)	
Length of stay			
No stay	103 (81.7)	113 (95.8)	.025
≥1 d	23(18.3)	2 (4.2)	
Follow up, No. (%)	121 (96)	111 (94.1)	.480
30-d readmission, No. (%)			
Yes	1 (0.8)	1 (0.8)	.480
No	120 (95.2)	110 (93.2)	
Not specified	5 (4.0)	7 (5.9)	
30-day ER visit, No. (%)			
Yes	10 (7.9)	6 (5.1)	.487
No	111 (88.1)	105 (89)	
Not specified	5 (4.0)	7 (5.9)	
Recurrence, No. (%)	2 (1.6)	2 (1.7)	.934
Early complication, No. (%)			
Hematoma	10 (7.9)	2 (1.7)	.333
Seroma	6 (4.8)	9 (7.6)	
Cellulites/infection	2 (1.6)	1 (0.8)	
Urine retention	0 (0)	4 (3.4)	
Not specified	9 (7.1)	9 (7.6)	

ANOVA, analysis of variance; ER, emergency room.

inguinal hernia repair were significantly lower than for the laparoscopic approach. However, OR and total hospital costs for repair of bilateral inguinal hernias were similar between the 2 groups.

The results of this analysis are comparable with those from other centers in the United States. Several authors have demonstrated that the primary difference in cost relates to OR expense. Khajanchee et al⁷ showed a \$795 incremental cost associated with the TEP approach relative to an open Lich-

tenstein repair. Similarly, Schneider et al⁴ found the total cost of laparoscopic herniorrhaphy to be higher than for the open approach (\$2,861 vs \$2,009). Combined with the current analysis, these studies suggest that the total cost of each procedure may be independent of local economic factors and may be directly attributable to surgical technique.

However, the perioperative benefits of laparoscopy are significant. Several studies have demonstrated enhanced recovery after surgery, shorter lengths of stay, and fewer periop-

Table 3.
Cost for Unilateral Inguinal Herniorrhaphy

Cost Center	Open, \$		Laparoscopic, \$		P
	Median	IQR	Median	IQR	
Preadmission	0.00	0.00–349.00	0.00	0.00–192.06	.008
PACU	243.93	198.68–292.27	259.02	234.38–283.99	.082
Day surgery	260.84	141.45–337.26	323.21	257.40–373.33	<.001
Total OR	2399.49	2015.54–2763.42	3092.03	2476.03–3509.21	<.001
Ward	0.00	0.00–59.32	0.00	0.00–59.32	.341
Other costs	467.03	429.34–511.10	520.57	470.21–558.28	.002
Total	3270.15	2775.63–3819.23	3723.66	3162.50–4375.28	<.001

IQR, interquartile range; OR, operating room; PACU, postanesthesia care unit.

Table 4.
Cost for Bilateral Inguinal Herniorrhaphy

Cost Center	Open, \$		Laparoscopic, \$		P
	Median	IQR	Median	IQR	
Preadmission	278.85	0.00–363.76	0.00	0.00–210.98	.142
PACU	284.00	251.44–345.26	244.66	231.61–284.15	.193
Day surgery	221.33	145.41–363.46	266.24	233.84–364.52	.222
Total OR	3471.86	3117.94–3702.82	3940.54	3195.835–4316.00	.145
Ward	66.02	32.98–296.86	0.00	0.00–62.67	.012
Other costs	588.28	526.83–608.59	571.27	545.84–644.78	.032
Total	4574.02	4214.81–6361.29	4662.89	4178.84–5228.31	.827

IQR, interquartile range; OR, operating room; PACU, postanesthesia care unit.

erative complications associated with a minimally invasive approach. As such, the incremental value associated with laparoscopic repairs of unilateral hernias may justify the increased relative cost (\$453.51). Further studies using hernia-specific outcomes are necessary to understand the economic utility and cost-effectiveness of each approach.

This study has several important limitations. The inherent selection bias that accompanies a retrospective study design cannot be ignored. Differences in patient demographics and surgeon preference may have influenced the technique used. In addition, the calculation of total hospital cost does not address the out-of-hospital expenses incurred by the patients. Furthermore, the indirect and societal costs associated with patient suffering, loss of productivity, and caregiver expense are difficult to quantify. Further studies are needed to evaluate the total soci-

etal cost associated with inguinal hernia repairs to determine the cost-effectiveness of each strategy.

A methodological limitation in the cost analysis is related to the institutional segmentation of expenses. OR costs are clustered as an aggregate of all expenses incurred in the OR. As such, with the current accounting system, it is difficult to distill the material contribution of operative time, general anesthesia, or equipment costs to the total expense. A refined case-costing system may provide additional insight into each component of patient care and highlight opportunities for efficiency.

CONCLUSIONS

In the setting of a Canadian tertiary academic hospital, the OR and total hospital costs of open inguinal herniorrhaphy

were significantly lower than for the laparoscopic approach. However, there was no statistical difference between OR and total hospital costs when comparing open surgical and laparoscopic techniques for repair of bilateral inguinal hernias. Given the perioperative benefits of laparoscopic surgery, further studies incorporating hernia-specific outcomes are necessary to determine the cost-effectiveness of each approach and to define the optimal treatment strategy.

References:

1. Rutkow IM. Demographics and socioeconomic aspects of hernia repair in the United States in 2003. *Surg Clin North Am.* 2003;83:1045–1051.
2. Bay-Nielsen M, Kehlet H, Strand L, et al. Quality assessment of 26304 herniorrhaphies in Denmark: a prospective nationwide study. *Lancet.* 2001;358:1124–1128.
3. Rosenberg J, Bisgaard T, Kehlet H, et al. Danish hernia database recommendations for the management of inguinal and femoral hernia in adults. *Dan Med Bull.* 2011;58:C4243–C4246.
4. Schneider BE, Castillo JM, Villegas L, Scott DJ, Jones DB. Laparoscopic totally extraperitoneal versus Lichtenstein herniorrhaphy: cost comparison at teaching hospitals. *Surg Laparosc Endosc Percutan Tech.* 2003;13:261–267.
5. Tanphiphat C, Tanprayoon T, Sangsubhan C, Chatamra K. Laparoscopic vs open inguinal hernia repair. A randomized, controlled trial. *Surg Endosc.* 1998;12:846–851.
6. Smink DS, Paquette IM, Finlayson SRG. Utilization of laparoscopic and open inguinal hernia repair: a population-based analysis. *J Laparoendosc Adv Surg Tech.* 2009;19:745–748.
7. Khajanchee YS, Kenyon ETAG, Hansen EPD, Swastrom LL. Economic evaluation of laparoscopic and open inguinal herniorrhaphies: the effect of cost-containing measures and internal hospital policy decisions on costs and charges. *Hernia.* 2004;8:196–202.
8. Benzaquen BS, Eisenberg MJ, Challapalli R, Nguyen T, Brown KJ, Topol EJ. Correlates of in-hospital cost among patients undergoing abdominal aortic aneurysm repair. *Am Heart J.* 1998;136(4 Pt 1):696–702.
9. Wordsworth S, Ludbrook A, Caskey F, Macleod A. Collecting unit cost data in multicentre studies: creating comparable methods. *Eur J Health Econ.* 2005;6:38–44.