Robotic Versus Video-Assisted Thoracoscopic Lung Resection During Early Program Development

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Background. **The objective of this study is to compare robotic portal (RP) to video-assisted thoracoscopic surgery (VATS) pulmonary resections for early stage non-small cell lung cancer with respect to health care resource utilization during the first year of a robotic surgery program in thoracic oncology.**

Methods. **Patients who underwent anatomic lung resections using RP (n = 42) or VATS (n = 96) for early stage non-small cell lung cancer between April 2014 and March 2015 at a single institution were identified. Patient-level case costing data for hospital and home care-associated resource variables were recorded. We adopted a health care payer perspective and 30-day posthospital discharge/death time horizon. Parametric or nonparametric tests were used as appropriate and incremental cost difference using 10,000 bootstrap samples using bias-corrected and accelerated method to generate 95% confidence intervals for total cost.**

Results. **Baseline demographic and clinical characteristics were comparable between the two groups. The median total hospital cost per patient was $15,247 (95% confidence interval: $15,643 to $18,945) in the RP cohort, compared with $12,131 (95% confidence interval: $13,218 to $15,879) in the VATS cohort (n = 96; $p < 0.001$). Longer operating times in the RP group were the main driver of higher hospital costs. Post-hoc analysis of mean operating room time for first 20 RP procedures versus remaining 22 RP procedures found a mean difference of 71 minutes ($p = 0.004$), resulting in an intraoperative cost difference of $883.38 ($p = 0.036$).**

Conclusions. **A micro-costing analysis demonstrates that RP pulmonary resection for early stage non-small cell lung cancer utilizes more health care resource dollars when compared with VATS during early program development, but offers similar perioperative outcomes.**

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Lung cancer is the leading cause of cancer mortality in the United States and Canada [1]. Early stage non-small cell lung cancer (NSCLC) is usually treated with surgical resection by anatomic pulmonary resection. An increasing number of operations are being performed by video-assisted thoracoscopic surgery (VATS) [2], and a recent randomized controlled trial [3] demonstrated that VATS should be the preferred method of pulmonary resection. When compared with thoracotomy, VATS pulmonary resection is less invasive and is associated with reduced postoperative pain, shorter length of stay, reduced chest drain duration, and greater ability to deliver adjuvant chemotherapy, resulting in reduced morbidity [4–7].

Despite these advantages, adoption of VATS resections has been slow over the past decade [8]. The VATS technique has been criticized for difficult hand-eye coordination, limited maneuverability, two-dimensional vision, and concerns about emergency control of bleeding, ultimately resulting in a steep learning curve (40 to 50 cases) [2, 9]. Micromechanics robotic systems were introduced in the late 1990s to overcome challenges associated with

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VATS resections. The da Vinci Si (Intuitive Surgical, Mountain View, CA) surgical system offers three-dimensional vision, endowrist technology, motion scaling, and tremor filtering. Hence, robotic-assisted thoracoscopic surgery is rapidly gaining popularity despite limited evidence of superiority. Two separate systematic reviews [10, 11] comparing robotic-assisted thoracoscopic surgery with VATS or thoracotomy concluded that the clinical outcomes of robotic-assisted procedures were superior to those of thoracotomy but not different from VATS. Subsequently, capital and disposable costs associated with robotic-assisted thoracoscopic procedures have been noted as the primary barrier to routine use of robotics for lung resection. However, there is limited information to guide surgeons, hospital administrators, policymakers, and payers regarding the major cost drivers and the difference in the inhospital resource utilization associated with robotic-assisted and VATS pulmonary resections.

The primary objective of this study was to compare inhospital and home care-associated resource utilization and costs for patients undergoing anatomic lung resections for NSCLC using the robotic portal (RP) versus the VATS approach. The second objective was to compare clinical outcomes between the two groups.

Patients and Methods

We conducted a retrospective review of consecutive adult patients who underwent anatomic lung resection for early stage NSCLC using RP or VATS at St. Joseph's Healthcare Hamilton (SJHH), a tertiary health care center in Ontario, Canada, from April 1, 2014, to March 31, 2015. Anatomic lung resection was defined as lobectomy or segmentectomy in which the individual branches of pulmonary arteries, veins, and bronchi are divided and ligated separately [12]. The first robotic lobectomy (RPL-4) at SJHH was performed at on April 1, 2014, using the da Vinci Si system, and hence, it was chosen as the starting point for this study. Before the robotics program, all thoracic surgeons at SJHH routinely performed VATS resections. After the robotics program was initiated, one junior surgeon switched to using RP for most of his cases, one senior surgeon continued to do a significant amount of VATS in addition to using RP, and two other junior surgeons continued to do all VATS. Ethics approval was sought from the Hamilton Integrated Research Ethics Board, and patient consent was waived owing to the nature of the study.

Operative Metrics and Clinical Outcomes

Intraoperative time (operating room [OR] time), days spent in intensive care unit or step-down unit, the total length of stay, and discharge location (home, respite, long-term care) were recorded. Intraoperative and postoperative complications (graded using Ottawa Thoracic Morbidity and Mortality classification [13]), conversion to thoracotomy, and reasons for conversions or reoperations were also extracted. Lymph nodes examined and tumor characteristics (location of tumor, laterality, greatest dimensions, focality, histologic type, histologic grade, and visceral invasion) were also noted.

Economic Outcomes

A micro-costing approach [14, 15] was adopted. The hospital payer's perspective was used to include all direct medical and nonmedical costs associated with an inpatient encounter from the time a patient arrives at the hospital for preoperative assessment and surgery-related hospital admission to the time patient is discharged or deceased. The hospital-related resource utilization and costs (direct medical and direct nonmedical) per patient were extracted from Ontario Case Costing Initiative database obtained from the Funding Reform and Case Costing Department. Direct medical costs included total departmental net costs such as inpatient and ambulatory care nursing, procedure, laboratory, imaging, pharmacy, allied health, and food services [16]. Direct nonmedical costs included overhead costs associated with managing a health care facility, such as administration, finance, human resources, and business operations [17].

Three measures were used to allocate the nonmedical costs per patient under the Ontario Case Costing Initiative methodology: total cost, square footage, and supply costs. Nonmedical cost centers such as finance, human resources, and business operations that are independent of patient care were allocated per patient based on total cost. Where there is a dependency between the nonmedical cost centers and patient care, square footage and total supply cost were used to allocate the dollar amount. Facility costs and housekeeping were allocated based on square footage, and materials management was allocated based on total supply cost. Unit costs for both primary surgeon and surgeon assistant were obtained from the Ontario Schedule of Benefits for Physician Services [16]. Anesthetist cost was calculated based on the time units used in the OR multiplied by the fee per time unit. Home care-related costs were obtained from the Integrated Comprehensive Care program, a community care program for patients undergoing thoracic surgery at SJHH for 30 days postoperatively. Cost pertaining to the capital, disposables, amortization, and maintenance of the laparoscopic or da Vinci Si system were excluded. Figure 1 exhibits a detailed outline of resources included in this cost analysis. All costs were collected in Canadian dollars for the fiscal year 2014 to 2015.

Statistical Analysis

We used descriptive analyses with count (and proportion), mean with standard deviation, or median with interquartile range (IQR) to describe the patient characteristics and clinical and economic outcomes as appropriate. Parametric tests (Fisher's exact test or independent samples Student's t test) or nonparametric tests (Mann-Whitney U test) were used to compare clinical and economic outcomes respectively. We generated 95% confidence intervals (CI) for the total costs for the RP group and the VATS group using the bias-corrected and accelerated method in IBM SPSS Statistics for Windows,