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Outside the operating room: How a robotics program changed resource utilization on the inpatient Ward

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HIGHLIGHTS

- Introducing robotics decreased inpatients for elective surgery.
- Robotics is associated with admitting a higher proportion of patients with complex medical issues.
- Number of surgeries increased while liberating beds and decreasing overall inpatient costs.

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ABSTRACT

Objective. To analyze the changes in the composition of the gynecologic oncology inpatient ward following the implementation of a robotic surgery program and its impact on inpatient resource utilization and costs.

Methods. Retrospective review of the medical charts of patients admitted onto the gynecologic oncology ward the year prior to and five years after the implementation of robotics. The following variables were collected: patient characteristics, hospitalization details (reason for admission and length of hospital stay), and resource utilization (number of hospitalization days, consultations, and imaging).

Results. Following the introduction of robotic surgery, there were more admissions for elective surgery yet these accounted for only 21% of the inpatient ward in terms of number of hospital days, compared to 36% prior to the robotic program. This coincided with a sharp increase in the overall number of patients operated on by a minimally invasive approach (15% to 76%, $p < 0.0001$). The cost per surgical admission on the inpatient ward decreased by 59% ($9827 vs. $4058) in the robotics era. The robotics program contributed to a ward with higher proportion of patients with complex comorbidities (Charlson ≥ 5: RR 1.06), Stage IV disease (RR 1.30), and recurrent disease (RR 1.99).

Conclusion. Introduction of robotic surgery allowed for more patients to be treated surgically while simultaneously decreasing inpatient resource use. With more patients with non-surgical oncological issues and greater medical complexity, the gynecologic oncology ward functions more like a medical rather than surgical ward after the introduction of robotics, which has implications for hospital-wide resource planning.

1. Introduction

The assessment of new technology in healthcare generally involves evaluating its safety, clinical effectiveness, economic impact, as well as effects on a local organizational level [1]. In order to fully capitalize on the introduction of a new technology in a hospital setting, changes in organizational processes and work flow need to also be measured and adapted accordingly [2].

The introduction of robotic surgery in gynecologic oncology is a prime example of a practice-changing technological conversion, allowing for an accelerated transition from laparotomy to minimally invasive surgery (MIS), especially for patients with endometrial and cervical cancers [3]. Since the introduction of the da Vinci Surgical System at

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our institution in December 2007, all the patients with cancer of the cervix undergoing surgery went from being operated on by laparotomy to robotics [4] and the rate of MIS for the treatment of endometrial cancer rose from 17% by laparoscopy to over 95% using robotics by 2012 [5]. The use of robotic surgery for ovarian cancer at our institution is also steadily increasing (66% in 2013).

Systematic reviews have demonstrated the safety and effectiveness of robotic surgery for endometrial and cervical cancer [6] with similar oncological outcomes [7,8] when compared to laparoscopy and laparotomy. The high initial equipment and ongoing maintenance costs of robotic surgery are offset by the decreased length of hospitalization and decreased morbidity [4,5,9–11], and its potential to convert cases to outpatient same-day surgeries [12,13]. From a hospital administration and resource allocation perspective however, there is a paucity of data evaluating the organizational impact of introducing a robotic surgery program in gynecologic oncology. The objective of this study was to analyze the changes in the demographics of hospitalized gynecologic oncology patients (i.e., the composition on the inpatient ward) with the introduction of robotic surgery and its impact on resource utilization and implications for the management of the inpatient ward.

2. Methods

A retrospective chart review was conducted on patients admitted onto the gynecologic oncology ward at a university-affiliated tertiary care hospital, the year prior to (2007) and 5 years after the implementation of the robotic surgery program (2013), at the time when a learning curve plateau and a steady state had been reached with the robotics program. Admissions data from January to December of 2007 and 2013 were collected from the hospital's database following approval from the hospital institutional review board.

The design of the study was a non-experimental pre-test/post-test study. With robotic surgery as the intervention, the variables were analyzed before (pre-test) and after (post-test) the introduction of robotic surgery. The selected unit of analysis was the absolute number of hospitalization days rather than the number of admissions because patients could be admitted once for a prolonged period on the ward or have multiple admissions in that year for short periods of time. In order to capture a snapshot of the inpatient ward in the pre-robotic and robotic era, the relative risk (RR) of being on the ward with a particular clinical characteristic was calculated by comparing the proportion of total days spent on the ward by patients with those characteristics in both eras. For example, if 20% of the hospitalization days were spent by patients admitted for bowel obstruction in 2007 and 40% in 2013, one would be twice as likely to see a patient on the ward for bowel obstruction in 2013. Since the length of stay is often shorter for robotic surgeries, we hypothesized that the introduction of a robotic surgery program would affect the length of stay for patients hospitalized for elective surgeries to a relatively greater extent compared to those hospitalized for non-surgical reasons. Thus, the analysis was divided to those who were admitted for elective surgery, “surgical”, and those admitted for any other reason, “non-surgical”. Patients who were discharged post-operatively and at any point re-admitted for surgical complications (e.g., wound infection) were included in the latter non-surgical group to create the distinction with patients admitted for the elective surgery itself. In addition, a decrease in post-operative complications following robotics [5], might have further decreased the overall yearly inpatient population and cost, by avoiding re-admissions for surgical complications.

Patient charts (both electronic and paper) from all admissions were reviewed for patient characteristics (e.g., age, cancer type and stage, comorbidities), hospitalization details (e.g., reason for admission, length of hospitalization, complications), and resources used. Cancer type and stage were retrieved post-hoc, after a final diagnosis could be made, rather than at time of admission where these are often not yet available. The Charlson comorbidity score [14–16] was used as a measure of comorbidities in our population; a score equal to or >5 was chosen as the dividing point for analysis because of the associated exponential increase in the risk of mortality. Moreover, while medical issues may arise during hospitalizations and diagnoses may change, the initial admitting diagnosis was used as the reason for admission, and although most ascites and pleural effusions are managed in an outpatient setting, some required admission for placement of a permanent drain or for pleurodesis.

Variables pertaining to inpatient resource utilization included number of hospitalization days (e.g., cost for room, nursing, pharmacy, laboratory, and overhead costs), specialty consultations (e.g., Internal Medicine, Surgical subspecialties, Palliative Care, Geriatrics, etc.), inpatient imaging studies (e.g., X-ray, MRI, CT, Ultrasound, PET), and inpatient procedures (e.g., drain insertion by interventional radiology or rectal stent insertion by gastroenterology). Resources used intraoperatively (e.g., the robot, surgical instrumentation, anesthesia, etc.) were excluded to focus on the inpatient ward. Average direct and indirect costs of each of the above-mentioned tests were obtained from hospital and departmental administrative databases, including MedGPS (Logibec Inc., Montreal, Canada), a data warehouse which archives patient-level administrative and clinical data on health care utilization and calculates the costs of resources used in the hospital. Capital costs of imaging machines were depreciated over the expected life of the machines and the average number of hospital-wide exams per year, and included in imaging costs. Physician remuneration fees were obtained from the provincial health insurance board (*Regie de l'assurance maladie du Quebec*). All cost estimates in this study were adjusted for inflation to 2016 Canadian dollars.

Statistically significant differences were also calculated for categorical and continuous variables using the Chi-squared test and the Wilcoxon rank-sum test, respectively. Statistical analysis was performed using commercially available statistical software, STATA 14 (StataCorp, Texas). A two tailed p-value < 0.05 was considered statistically significant throughout the study.

3. Results

3.1. Description of admissions: surgical vs. non-surgical

There were more individuals admitted in 2013 than 2007 (291 vs. 246 patients admitted at least once) and among these patients, some were admitted multiple times during the year and there were overall more admissions to the gynecologic oncology service in 2013 than 2007 (395 vs. 356). Despite more admissions, the overall total number of hospitalization days decreased by 12% (2964 vs. 3358 in 2013 and 2007 respectively).

There were 207 admissions for elective surgery (52% of total admissions) in 2013 compared to 163 (46%) in 2007. Of these, the number of elective surgeries performed with a minimally invasive approach increased to 76% (94.3% of which were performed robotically) in 2013 from 15% (all by laparoscopy) in 2007 ($p < 0.0001$).

Fig. 1 illustrates the total number of bed days on the gynecologic oncology ward by reason for admission in 2007 and 2013. Despite performing more surgeries in 2013, only 21% of the inpatient bed days were dedicated to patients admitted for surgery, compared to 36% in 2007, saving 585 bed-days for surgery. This is likely due to the increase in number of patients who underwent robotic surgery resulting in a decrease in the median length of stay for surgical patients to 1 day in 2013 from 6 days in 2007 ($p < 0.0001$). Thus, patients were less likely to be on the ward for elective surgery in 2013 (RR 0.58; 95%CI 0.54 to 0.64). Moreover, of the patients admitted for surgical reasons in 2013, 50% of the days on the ward were dedicated to post-laparotomy patients even though only 17% of surgeries were done by laparotomy.

For non-surgical admissions, the number of hospitalization days increased (79% vs. 64% of the inpatient bed days in 2013 and 2007; $p < 0.0001$) for an additional 191 days, without a significant change in median length of stay (5 vs. 6 days, $p = 0.1$). Among these patients,