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Utilization and costs associated with robotic surgery in children

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ABSTRACT

Background: To evaluate utilization and costs associated with robotic surgery in children.
Materials and methods: We identified patients in the Pediatric Health Information System database who underwent robotic surgery between October 2008 and December 2013. After determining the six most frequently performed surgeries in this group, we identified patients who underwent equivalent nonrobotic surgeries at the same hospitals. Equivalent surgeries were defined as open procedures for urology and laparoscopic procedures for general surgery. We examined trends in the numbers of surgeries performed and compared hospitalization costs between patients undergoing elective robotic and nonrobotic surgery for each procedure.
Results: The number of robotic surgeries performed increased by 19.8% per year ($P < 0.001$). The most common robotic surgeries performed were pyeloplasty ($n = 760$), ureteral reimplantation ($n = 351$), nephrectomy ($n = 145$), partial nephrectomy ($n = 56$), gastrointestinal antireflux procedure ($n = 61$), and cholecystectomy ($n = 46$). Total increase over time was primarily driven by increases in urologic surgeries (17.4% per year, $P < 0.001$). Postoperative length of stay was shorter after robotic surgeries than equivalent open urologic surgeries but not equivalent laparoscopic general surgery procedures. Total hospitalization costs were higher for robotic surgeries than equivalent urologic or general surgery procedures.
Conclusions: Use of robotic surgery in pediatrics is increasing especially in the management of urologic conditions. Costs of robotic surgery-associated hospitalizations were higher than nonrobotic surgery-associated hospitalizations.

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1. Introduction

The first pediatric case series of robotic surgery was published in 2001 [1] Since then, the scope of robotic surgery in children has expanded, with literature describing its use in multiple specialties including urology, general surgery, otolaryngology, and orthopedic surgery [2–10]. Many large pediatric centers in the United States have either purchased robotic systems or have secured access to these systems through partnerships with adult facilities. Although there is currently great interest in the application of robotic surgery in pediatrics, existing data on use of robotic surgery in pediatric patients are limited to single-institution experiences [3,5,11–15].

Advantages noted with adult robotic surgery compared with laparoscopic techniques include improved ergonomics, tremor filtering, three-dimensional visualization, and more intuitive instrument handling [16–21]. Initial studies outlined many technical and safety concerns specific to robotic surgery in the pediatric population including smaller working space to avoid instrument collision and potential mechanical trauma, access to the entire abdominal cavity based on port positioning, and larger port and instrument sizes [2,22–25]. One major disadvantage is cost including capital and maintenance costs. Large programs that perform high-volume surgeries with increased complexity may be the only centers in a position to justify this cost [3,5,26].

The impact robotic surgery utilization has had on the cost and quality of health care are not well understood. The objectives of this study were to (1) describe trends in the use and costs of robotic surgery in a national cohort of children and (2) determine the most commonly performed robotic surgeries and compare their cost with cohorts of children undergoing equivalent nonrobotic surgeries.

2. Material and methods

This study used data from the Pediatric Health Information System (PHIS), which includes comprehensive administrative data from 47 of the largest tertiary children's hospitals in the United States. It also includes data on demographics as well as diagnoses and procedures using International Classification of Diseases, Ninth Edition, Clinical Modification codes (ICD-9-CM) [27]. The PHIS database was queried for patients under age 18 y who underwent any robotic surgery, as designated by the ICD-9-CM procedure code 17.4X, at a hospital that contributed inpatient data to the PHIS database continuously from October 2008–December 2013 and at which more than five robotic surgeries were performed during the study period. The six most frequently performed robotic surgeries were identified based on the principal surgical procedure ICD-9-CM code that was documented for the same operative episode as the 17.4X code. The PHIS was then queried for patients at the same hospitals who were under age 18 y and underwent an open or laparoscopic nonrobotic surgery with one of the selected procedure codes. Laparoscopic nonrobotic surgeries were identified by the presence of ICD-9-CM procedure code 54.21 or 54.51 during the same operative episode as the surgical procedure under evaluation or by the surgery itself being defined as laparoscopic (e.g., 51.23 for laparoscopic cholecystectomy and 44.67 for laparoscopic procedures for creation of esophagogastric sphincteric competence). All other nonrobotic surgeries, including those for which an ICD-9-CM procedure code for laparotomy (54.1X) was present in the same operative episode as any of the previously listed codes, were defined as open nonrobotic surgeries.

We calculated the quarter-to-quarter change in the number of robotic and nonrobotic surgeries performed. We compared preoperative demographic and clinical characteristics, length of stay, and total hospitalization costs for the inpatient stay associated with the surgery between pediatric patients undergoing robotic and equivalent nonrobotic elective surgery. Equivalent nonrobotic surgery was defined as open urologic surgery or laparoscopic general surgery. Among urologic procedures, only 195 comparable nonrobotic laparoscopic urologic surgeries were identified over the study period. The infrequency of laparoscopy in pediatric urology has been shown elsewhere [28–32] and is likely due to the technical challenge involved with pediatric laparoscopic pyeloplasty and partial and radical nephrectomy as well as the acceptance of open cross-trigonal ureteral reimplantation as the standard of care for pyeloplasty. Therefore, because open surgery is the standard of care for the four most commonly performed urologic procedures, the urologic analyses compared robotic procedures to open procedures. For the general procedures, robotic surgery was compared with laparoscopic procedures. Elective surgeries were defined as all surgeries performed on the day of admission in patients not admitted through the emergency department. Patients were defined as having a concurrent operative procedure if another operative procedure with a different ICD-9-CM procedure code was performed during the same operative episode as the surgery under consideration. Complex chronic conditions were defined based on ICD-9-CM diagnosis codes reported at the associated admission [33]. Hospitalization costs were calculated as the total charges for care during the inpatient stay associated with the surgery, adjusted for inflation to 2013 US dollars using the hospital-and-related services component of the consumer price index and converted to costs using hospital-specific ratios of cost to charge estimates. These ratios are reported to the Center for Medicare and Medicaid Services and used to convert reported charges to estimates of their true economic costs. They are provided for specific institutions as well as specific categories of billable services and products within that institution.

The mean quarterly percentage changes in the number of robotic surgeries overall and in the number of individual types of robotic surgeries performed across all hospitals were evaluated with Poisson regression models and reported as compound annual growth rates. The mean quarterly increases in the proportion of individual types of surgeries that were performed robotically were estimated using general linear models. Preoperative and postoperative variables were compared between treatment groups using Mann–Whitney U tests for continuous variables and chi-squared tests for categorical variables. All analyses were performed using SAS version 9.3 (SAS Institute, Cary, NC). All tests were two-tailed, and $P < 0.05$ was considered statistically significant.