Learning Curve of Robotic Assisted Pyeloplasty for Pediatric Urology Fellows

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Abbreviations and Acronyms

UPJO = ureteropelvic junction obstruction

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Study received local institutional review board approval.

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Purpose: Little is known about the learning curve of robotic surgery for surgeons in training. We hypothesized that pediatric urology fellows could attain proficiency in robotic pyeloplasty, defined as operative time equivalent to that of an experienced robotic surgeon, within the 2-year time frame of fellowship.

Materials and Methods: From 2006 to 2010 we performed a prospective cohort study of pediatric robotic pyeloplasty done by 4 pediatric urology fellows and 1 pediatric urology attending surgeon. We recorded operative times and surgical outcomes of the total of 20 consecutive robotic pyeloplasties performed by the 4 pediatric urology fellows (80 cases) and a random sample of 20 performed by the attending surgeon. Multivariate linear regression was used to determine the change in operative time for each case done by fellows and estimate the number of cases needed for fellows to achieve the median operative time of the attending pediatric urologist.

Results: Fellow operative time decreased at a constant average rate of 3.7 minutes per case (95% CI 3.0-4.3). Fellows were projected to achieve the median operative time of the attending surgeon after 37 cases. No operative complications or failed pyeloplasties occurred.

Conclusions: The operative time for robotic pyeloplasty performed by fellows consistently decreased with cumulative surgical experience. These data can be used to help establish benchmarks of robotic pyeloplasty for pediatric urology, assuming appropriate exposure to robotics and adequate case volume.

Key Words: kidney; robotics; learning curve; surgical procedures, minimally invasive; clinical competence

The introduction of robotic surgery has dramatically increased the choice of operations available for common urological diseases and congenital anomalies. Robotic approaches to urological surgery such as radical prostatectomy and pyeloplasty are now performed routinely. The introduction of these novel procedures significantly increased the technical skills that urology residents and fellows must acquire. Also, the time available for learning new operations is finite, given work hour restrictions and case volume, which challenge the goal of fellowship programs to produce proficient surgeons.

There is a growing body of literature on the learning curve associated with robotic urological surgery. However, almost all published series pertain to operations done primarily in adults and the definition of learning curve differs among studies.[1–3] The only study of robotic surgery in children focused on the

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learning curve associated with attending surgeons acquiring proficiency with robotic pyeloplasty.[4] To our knowledge no group has addressed the learning curve of robotic operations for surgeons in training.

Pediatric urologists reported that the ability to perform robotic surgery is an essential skill that should be learned during training.[5] Understanding the time required for fellows to learn novel operations such as robotic pyeloplasty is critical, given that the pediatric urology fellowship is a fixed 2-year period, after which structured mentorship is limited. Ascertaining the learning curve for robotic pyeloplasty would allow for pediatric urology fellowship programs to determine the optimal structure of the fellowship to enable trainees to acquire the requisite skills before completing training.

We performed a prospective cohort study to determine the learning curve for pediatric urology fellows performing pediatric robotic pyeloplasty. We defined the learning curve as the improvement in robotic console time that occurs with mentored operative experience, considering surgical complications and outcomes. We tested the hypothesis that pediatric urology fellows have the potential to attain proficiency in robotic pyeloplasty during the time frame of a pediatric urology fellowship. In doing so, we estimated the number of cases needed for fellows to attain proficiency.

METHODS

Study Design

We performed a prospective cohort study between 2006 and 2010 at a single institution. The cohorts included patients 18 years or younger with UPJO in whom robotic pyeloplasty was done entirely by an experienced attending surgeon (PC) or by one of 4 pediatric urology fellows under attending surgeon direct supervision. Fellow cases were a consecutive series of operations in which the fellow performed greater than 75% of the console time. The portion of the case done by the fellow changed as experience increased. Typically, the progression was renal dissection and then anterior anastomosis, followed by posterior anastomosis. The 20 attending surgeon cases included a random sample of cases performed during the study period in which the attending performed 100% of the case. This was most often due to unavailability of the fellow to participate in the operation. The sample of 20 attending surgeon cases was selected from eligible cases using a random number generator.

Children 1 to 18 years old with UPJO were eligible for study inclusion. Exclusion criteria included those in whom a concurrent operation was performed, eg pyelolithotomy, and those in whom a ureteral stent had been placed before the scheduled pyeloplasty. Pre-stented patients were excluded because in the surgeon experience prior stenting increases operative difficulty. Also, at the time of the study it was standard practice to place a stent, should it be needed, in antegrade fashion at pyeloplasty.

The primary outcome was operative time, defined as robotic console time in minutes. The time required for anesthesia, trocar placement, robot docking and closure were excluded from analysis to decrease inherent variability in the outcome measure and focus analysis on the question at hand, that is actual operative time. Console switches were recorded on a spreadsheet at the time of occurrence. Secondary outcomes included surgical success, defined as hydronephrosis stability or improvement on postoperative ultrasound, and operative complications. All patients were followed for 2 years after pyeloplasty.

The primary explanatory variable was surgical expertise (pediatric urology fellow vs attending urological surgeon). Additional patient characteristics and operative variables were recorded, including gender, age, obstruction side, antegrade ureteral stent placement during pyeloplasty and UPJO etiology (crossing vessel vs intrinsic narrowing vs fibroepithelial polyp vs failed pyeloplasty). Heineke-Mikulicz repair was done for intrinsic obstructions and dismembered pyeloplasty was performed in patients with fibroepithelial polyps and crossing vessels. This study was approved by the local institutional review board.

Statistical Analysis

The operative time of fellow cases was defined as the median operative time of the 4 fellows during sequential cases. The median was chosen to decrease the influence of outlying values. Because fellows did not always perform the entire case, total fellow operative time was estimated to adjust for the proportion of attending surgeon involvement using the equation, estimated total operative time = actual operative time − [(percent of case performed by attending surgeon × median attending surgeon operative time) + (percent of case performed by attending surgeon × individual fellow operative time for that case number)]. Unless otherwise noted, fellow operative time reflects this adjusted time.

Linear regression was used to determine the relationship between the number of fellow cases and operative time. The number of cases at which point fellows would achieve the attending surgeon operative time was estimated by the point on the x axis (case number) at which the regression line crossed the median operative time for the attending surgeon. An interaction term ($cases^2$) was included in an alternative model to test whether fellow operative time increased at a nonlinear rate. We performed sensitivity analysis using uncorrected operative times as the dependent variable.

Post-regression analytics confirmed that linear regression model assumptions were met. We compared the cohort of patients operated on by the attending surgeon and those operated on by fellows using the Fisher exact test for nominal variables, and Kruskal-Wallis ANOVA and the Mann-Whitney U test for continuous variables. The Kruskal-Wallis test was also used to determine whether the proportion of fellow cases done by the attending surgeon differed among the 4 fellows. Linear regression was used to determine whether the proportion of fellow cases done by the attending surgeon changed during the study period. Statistical analysis was performed with Stata® 11.