

# Evaluation of Initial Experience and Comparison of the da Vinci Surgical System With Established Laparoscopic and Open Pediatric Nissen Fundoplication Surgery

Daniel R. Copeland, MD, Cristiano Boneti, MD, Evan R. Kokoska, MD,  
Richard J. Jackson, MD, Samuel D. Smith, MD

## ABSTRACT

**Background:** Robot-assisted surgery must be evaluated before its acceptance as an option for standard therapy in the pediatric population. Our objective is a comparison of results using the robot system with results for the laparoscopic and open approaches.

**Methods:** Following IRB approval, robot-assisted procedures were case-matched with controls, selected from 1994 to 2005. Data for 150 Nissen cases were divided equally into 3 groups [robot (R), laparoscopic (L), and open (O)], comparing surgical times, length of hospitalization, and outcomes.

**Results:** The average age (R =  $117 \pm 64$  months, L =  $107 \pm 71$  months, O =  $85 \pm 55$  months,  $P < 0.05$ ) and weight (R =  $37 \pm 23$  kg, L =  $33 \pm 24$  kg, O =  $24 \pm 17$  kg,  $P < 0.05$ ) of the open group were lower comparatively. Robot operative times proved significantly longer compared with laparoscopic and open time (R =  $160 \pm 61$  min, L =  $107 \pm 31$  min, O =  $73 \pm 27$  min,  $P < 0.05$ ). The robot had 2 conversions (2/50, 4%), comparable to the laparoscopic conversion rate (1/50, 2%). Open cases resulted in longer hospitalization [R =  $2.94 \pm 4.5$  days, L =  $3.54 \pm 7.8$  days, O =  $3.5 \pm 2.8$ ,  $P < 0.05$ ]. Complication rates were equivalent between groups. The most common complication with the da Vinci and laparoscopic approaches was tight wrap requiring dilation [R = 4/50 (8%) and L = 3/50 (6%)].

**Conclusion:** Robot-assisted surgery is equivalent to standard laparoscopic surgery in terms of complications and length of stay, with both having significantly increased operation times but reduced length of stay compared with open surgery. Further experience with this technology is needed to overcome the learning curve and reduce operative times.

**Key Words:** Robot-assisted surgery, Nissen fundoplication.

University of Arkansas for Medical Sciences, Little Rock, Arkansas, USA (Drs Copeland, Boneti).

University of Arkansas for Medical Sciences and Arkansas Children's Hospital, Little Rock, Arkansas, USA (Drs. Kokoska, Jackson, Smith).

Address reprint requests to: Samuel D. Smith, MD, Chief of Pediatric General Surgery, Arkansas Children's Hospital, Mail Slot 837, Little Rock, AR 72202, USA. Telephone: 501 364 2942, Fax: 501 364 1516, E-mail: SmithSamuelD@uams.edu

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## INTRODUCTION

The FDA-approved da Vinci surgical system<sup>1</sup> is a novel approach to perform minimally invasive surgery and is considered a "second revolution" in surgery after the introduction of laparoscopic surgery. This system was introduced in April 2003 at our institution, with 90 pediatric patients undergoing a variety of procedures performed by our surgical group. Among these procedures, the Nissen fundoplication and cholecystectomy were the most common. Several reports<sup>1-3</sup> have been published on this subject, concluding that it is a feasible, safe alternative. Despite some of its potential benefits, there has yet to be any improvement shown by using the robot over the standard laparoscopic or open technique. Our objective in this study was to compare results using the robot system with that of laparoscopic and open techniques in our pediatric patients to determine the potential for acceptance as a standard approach in this population.

## METHODS

Following IRB approval, 150 charts of patients who underwent Nissen procedures from 1994 to 2005 were divided into 3 treatment groups defined by technical approach, either robotic (R) (n=50), laparoscopic (L) (n=50), or open (O) (n=50). Groups were case-matched and performed by several surgeons and residents, under the care of one of the 3 staff surgeons at our facility.

The robot system used was the da Vinci (Intuitive Surgical, Mountain View, CA, USA). In most cases, 3 robotic arms were used. The fourth arm was used in a minority of pediatric patients due to the short distance between ports leading to the restricted movement of the working arms outside the patient. We now use a 5-mm scope in addition to the 11-mm stereoscopic scope more typically used.

All cases were performed with the patient in a reverse Trendelenburg position under general anesthesia and complete paralysis with an age-appropriate esophageal dilator in place. Port placement with the robot followed laparoscopic standards with the exception of ports being placed more distant to one another to allow broader external movements.

In open cases, unless the patient had a previous midline scar, a left subcostal incision was performed. Regardless of the surgical approach, once the equipment was inside the abdominal cavity, identical steps were taken to dissect the gastroesophageal junction and wrap the gastric fundus around the esophagus.

Descriptive and analytical statistics were applied to compare surgical times, length of hospitalization, and outcomes using Kruskal-Wallis and Tukey tests for continuous data and the chi-square test for nominal data.

**RESULTS**

In the 150 Nissen cases included in this study, patients were younger and smaller in the open group (85±55 months, 24±17 kg, P<0.05) compared with those in the robotic (117±64 months, 37±23 kg) and laparoscopic groups (107±71 months, 33±24 kg) (Table 1). The most common indication for the procedure was reflux refractory to medical management either as the sole reason or associated with failure to thrive or neurological impairment, or both of these [R = 39(78%), L = 50(100%), O = 34(68%)]. Other indications include a failed previous antireflux procedure, reflux associated with oromotor dysfunction, hiatal hernias, aspiration with an acute life-threatening event, and esophageal stricture.

Robot operative times proved significantly longer compared with times for laparoscopic and open procedures (R 160±61 min, L = 107±31 min, O = 73±27 min, P<0.05). The number of gastrostomy tubes done in addition to the Nissen fundoplication in the robot group were similar to that of the other groups [R = 17/50 (34%), L = 24/50 (48%), O = 11/50 (22%), P>0.05]. The robot group experienced 2 conversions to the open approach (2/50 4%), comparable to the laparoscopic conversion rate (1/50

2%). Open cases resulted in longer hospitalization compared with the robot-assisted cases [R = 2.94±4.5 d, O = 3.5±2.8, P<0.05]. Complication rates were equivalent between groups, including hiatal hernia, tight wrap requiring dilatation, and wound infection [R = 7(14%), L = 8(16%), O = 5(10%), P=0.387]. The most common complication with the da Vinci and laparoscopic approaches was a tight wrap, requiring dilatation [R = 4/50, 8% and L = 3/50, 6%], whereas in the open series, wound infections were more common (2/50, 4%). On 30-day follow-up, the presence of transient symptoms including dysphagia, abdominal pain, feeding aversion, and gas bloating were equivalent [R = 15 (30%), L = 14(28%), O = 6(12%), P=0.06].

**DISCUSSION**

In our experience, the robot proved to be an acceptable approach for laparoscopic Nissen fundoplication. This parallels the findings reported on early experiences from other centers.<sup>1,4-8</sup> As in previous randomized trials, our experience with Nissen fundoplication shows comparable efficacy of the robotic and laparoscopic approaches, with similar morbidity.<sup>5,6</sup> The laparoscopic procedure, whether da Vinci assisted or not, demonstrated a slight reduction in hospital stay compared with the open technique.<sup>4</sup>

Conversion to open was similar between the groups. Of the 2 robot cases that were converted to open, one was due to intraoperative hypotension and arrhythmia and the other due to difficult dissection following failed prior repair. The laparoscopic group had one conversion that was due to a gastric perforation. Postoperatively, the presence of transient symptoms was similar between groups, reaching up to 30%. There was a trend towards fewer symptoms in the open group that may be due to achieving a tighter wrap in the robot and laparoscopic groups lead-

**Table 1.** Patient Demographics, Surgical Times, and Complication Rates According to Surgical Approach

	Robot	Laparoscopic	Open	P*
Age (months)	117 ± 64	107 ± 71	85 ± 55	0.049*
Weight (kg)	37 ± 23	33 ± 24	24 ± 17	0.038*
Operative time (min)	160 ± 61	107 ± 31	73 ± 27	<0.001*
Length of stay (days)	2.94 ± 4.5	3.54 ± 7.8	3.5 ± 2.8	<0.001*
Gastrostomy	17/50 (34%)	24/50 (48%)	11/50 (22%)	0.337
Conversions	2/50 (4%)	1/50 (2%)		
Complications	7(14%)	8 (16%)	5 (10%)	0.668

\*Denotes significant difference between the Robot vs. Open group.

ing to more gas bloating and abdominal complaints. However, in long-term follow-up, all patients achieved symptomatic relief.

The learning curve for the da Vinci system played a key role in our surgical times despite previous reports.<sup>1,4,6,10,11</sup> The 50 robotic cases in our study were distributed among the 3 surgical faculty and 4 pediatric surgery residents during this time. In addition to this, the robot requires several extra steps to achieve assembly in a sterile fashion and to change the instruments. We believe these factors combined would explain why the robot-assisted procedures resulted in both longer operative and total room times compared with the open series. We expect reduced surgical times once the operating surgeons overcome this 10-case learning curve and reduced setup time as well with more practice and repetition of use. Therefore, like others, we have found no proven outcome benefits of using the robot in low- or medium-difficulty cases compared with the laparoscopic approach.<sup>6,9,12</sup>

Potential benefits over standard laparoscopy include 3-dimensional image quality, camera steadiness, and the dexterity of the instrumentation for dissection and suturing.<sup>1,2,3</sup> This combined with the improved image quality should lead to improved surgical precision.

To better delineate cases that benefit most from each one of the 3 techniques, randomized prospective trials utilizing surgeons past the learning curve is required. We are currently continuing our series and are looking forward to the results.

## CONCLUSION

Robot-assisted surgery is equivalent to standard laparoscopic surgery in terms of complications and length of stay, with both having significantly increased operation times but reduced length of stay compared with open surgery. Improved results are expected once the learning curve is overcome. However, potential outcome benefits have yet to be proven.

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