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Comparing laparoscopic versus open Ladd's procedure in pediatric patients☆

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ABSTRACT

Background/purpose: The objective of this study was to perform a comparative analysis of laparoscopic versus open Ladd's procedure on 30-day postoperative outcomes.
Methods: All elective Ladd's procedures performed on patients with intestinal malrotation in the 2013–2014 National Surgical Quality Improvement Program Pediatric were identified. A propensity score-matched analysis was used to account for baseline differences between groups, and generalized estimating equations (GEEs) were used to compare 30-day outcomes between open versus laparoscopic groups.
Results: Fifty-eight (18.6%) patients underwent laparoscopic Ladd's while 253 (81.4%) underwent an open technique. After propensity score matching, 53 laparoscopic cases (38.1%) and 86 open cases (61.9%) were identified and compared for outcomes. Total length of stay was shorter for the laparoscopic group compared to the open group (6 vs. 4 days, $p < 0.001$). Postoperative length of stay was shorter for the laparoscopic group as well (5 vs. 4 days, $p < 0.001$). Postoperative complications occurred in 5 laparoscopic cases (9.4%) and in 18 open cases (20.9%), but did not meet statistical significance ($p = 0.08$). One laparoscopic patient (1.9%) and 8 open patients (9.3%) required hospitalization beyond 30 days, but this also did not meet significance ($p = 0.08$).
Conclusions: In a matched analysis, laparoscopic Ladd's led to shorter hospital stays than open Ladd's in the initial 30-day postoperative period. Short-term benefits of laparoscopic Ladd's lend support for using additional resources to perform multi-institutional studies to compare differences in long-term outcomes between laparoscopic and open Ladd's.
Type of study: Therapeutic
Level of evidence: III

The Ladd's procedure has traditionally been performed using an open approach, but an increasing number of surgeons are performing this operation using a laparoscopic surgical technique [1–11]. Potential benefits of a laparoscopic approach include a decreased postoperative length of stay (LOS), decreased postoperative pain, and smaller incisions with less scarring and improved cosmesis. Potential drawbacks of a laparoscopic surgical approach include increased operative times and the potential that laparoscopy reduces postoperative adhesions and could lead to susceptibility to volvulus [1,2,12]. Conversely open operations may lead to increased adhesion formation with subsequent potential for long-term complications such as bowel obstruction. A study of 173 patients with malrotation by Hsiao et al. showed that open operations or conversion from laparoscopic to open was more common in neonates and 8% developed adhesive small bowel obstruction with follow-up ranging from a mean of 1–7 months depending on age group [13]. Overall, outcomes from open and laparoscopic Ladd's are limited with mainly cases series that are confounded by differences in patient characteristics.

The current study identifies a cohort of patients with malrotation in the National Surgical Quality Improvement Program Pediatric (NSQIP-Pediatric) database to compare open and laparoscopic Ladd's. Although limited to 30-day outcomes, the standardized prospectively collected data in NSQIP-Pediatric allows for risk adjustment and outcome assessment across patients treated at different institutions. The objective of this study was to perform a severity of illness matched multi-institutional comparison of 30-day outcomes after open and laparoscopic Ladd's procedures. If laparoscopic Ladd's is found to have significant short-term benefits in a matched analysis, then additional multi-institutional long-term comparative studies are warranted.

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1. Materials and methods

The National Surgical Quality Improvement Project Pediatric (NSQIP-Pediatric) is a multicenter and multispecialty program managed by the American College of Surgeons and American Pediatric Surgical Association to collect surgical outcomes data for patients under the age of 18 years. It specifically evaluates and reports peer-reviewed, risk-adjusted 30-day postoperative outcomes on systematically sampled surgical patients from participating institutions for the purpose of baseline analysis and quality improvement aims. Trained surgical clinical reviewers are responsible for maintaining and collecting all data. Current procedural terminology (CPT) codes are used to categorize cases. More than 124 data elements, including demographic information, surgical profile, preoperative and intraoperative variables, postoperative characteristics, and discharge variables, are collected for patients selected by the ACS NSQIP 8-day cycle-based systematic sampling of 35 procedures per cycle [14–16].

1.1. Ladd's procedure

All elective Ladd's procedures performed on patients less than 18 years of age with intestinal malrotation in the 2013 and 2014 NSQIP Pediatric database were identified using CPT codes. Urgent/emergent cases were excluded as many surgeons would not perform an urgent or emergent Ladd's procedure using the laparoscopic technique. Patients were defined as undergoing a laparoscopic Ladd's procedure if they had a primary, concurrent, or other CPT code of 44,055. Patients that underwent major procedures that may have affected the Ladd's operative approach (open vs. laparoscopic) during the same operation as the Ladd's procedure were excluded. These procedures were defined by independent review of a list of all additional procedures performed during the same operation as the Ladd's procedure independently by three of the authors (JTH, JBM, and PCM); discrepancies were resolved by consensus (Supplemental Table 1).

1.2. Minimally invasive versus open procedures

Patients were separated into two cohorts: those who underwent an open or a laparoscopic procedure. The NSQIP codes were used to define open versus laparoscopic cases. For codes of "Minimally invasive" technique only, these were classified as laparoscopic surgery cohort. For cases of "Minimally invasive and Open," these were assumed to be laparoscopic converted to open procedures and were placed in the open surgery cohort. For cases of "Open or Not applicable," these were categorized as the open surgery cohort.

1.3. Patient characteristics and outcomes

Demographic, clinical, and 30-day outcome characteristics between patients who underwent an open versus a laparoscopic Ladd's procedure were compared. The primary outcome was length of stay comparing laparoscopic versus open technique. Secondary outcomes included postoperative characteristics including complications. Patients with pulmonary risk factors were defined as any patient with a diagnosis of asthma, chronic lung disease, structural pulmonary disorder, cystic fibrosis, preoperative ventilator dependence, preoperative oxygen requirement current pneumonia, or a preoperative tracheostomy. Neurologic risk factors were defined as history of a cerebrovascular accident (CVA), tumor involving the central nervous system (CNS), seizure disorder, cerebral palsy, structural CNS abnormality, neuromuscular disorder, or a coma. Operation time was defined as the length of time between the initial surgical incision and closure of all surgical incisions. Total anesthesia time was defined as the length of time between initiation of induction of general anesthesia and handoff of the patient's care from the anesthesia provider to the postoperative care provider, inclusive of operation time. Wound complications were defined as superficial surgical site infections (SSIs), deep SSIs, organ or organ space SSIs, and wound disruption. Respiratory complications were defined as pneumonia, unplanned intubation, pulmonary embolism, and any ventilator dependence. Urinary tract complications included acute renal failure, progressive renal insufficiency, and urinary tract infection. Central nervous system complications included coma >24 hours, seizure, and nerve injury. Cardiovascular complications included cardiac arrest requiring cardiopulmonary resuscitation, CVA, and venous thromboembolism. Other complications included graft or prosthesis failure, postoperative systemic sepsis, nutritional requirements, unplanned reoperation, or death. Other outcomes included postoperative LOS, unplanned readmission, and transfusion performed intraoperatively or within 72 hours of surgery. All categorical outcomes, including complications, are reported as any occurrence of the event within 30 days of surgery.

1.4. Statistical analysis

Continuous variables were compared using Wilcoxon rank-sum tests and categorical variables were compared using Pearson chi-square tests or Fisher exact tests where appropriate for open versus laparoscopic Ladd's procedures. A propensity score-matched analysis was performed in order to adjust for potential differences in preoperative factors between the laparoscopic and open groups. Propensity scores were estimated using a separate logistic regression model including all preoperative variables with a $p < 0.20$ in univariable analyses and first-order interactions with $p < 0.15$. Laparoscopic and open patients were then matched using 1:2 nearest neighbor matching within calipers of width equal to 0.20 times the standard deviation of the logit of the propensity score [17–19]. Patients without an eligible match were excluded. Weighted standardized differences for the preoperative variables in the matched groups were computed. In order to test differences in postoperative outcomes between the laparoscopic and open groups, and to account for the potential correlation of outcomes within the propensity score-matched pairs and triads, a GEE model with a negative binomial distribution (log link) was used for the analysis of postoperative LOS, and a GEE model with a binomial distribution (logit link) was used for the analysis of binary postoperative outcomes. Any preoperative variables that had a standardized difference ≥0.15 were added to the GEE models for further adjustment. Several sensitivity analyses were conducted, and results were congruent with the findings from the original analysis.

All analyses were performed using SAS 9.3 (Cary, NC). The propensity score matching was performed using the "gmatch" SAS macro [20]. All tests were 2-tailed and $p < 0.05$ was considered statistically significant.

2. Results

2.1. Patient inclusion and perioperative data

Of the 311 children who met inclusion criteria, 253 (81.4%) underwent an open Ladd's procedure and 58 (18.6%) underwent a laparoscopic Ladd's. Of the 253 open cases, 22 started as laparoscopic attempts (8.7%). Compared to patients undergoing a laparoscopic Ladd's, patients undergoing open Ladd's were more likely to be neonates, be premature, have cardiac risk factors, and less likely to be undergoing their Ladd's on the day of admission (Table 1). After propensity score matching, 53 patients met inclusion criteria in the laparoscopic group (38.1%), and 86 met inclusion in the open group (61.9%). Demographics and preoperative characteristics were well balanced in each group after propensity score matching (Table 2). Compared to matched patients in the open group, unmatched patients in the open group represented a higher risk group of patients that were more likely to be neonates ($p = 0.008$), have cardiac ($p = 0.07$) or other congenital anomalies ($p = 0.01$), have a higher ASA class ($p = 0.07$), require preoperative nutrition ($p = 0.04$), and have surgery not on the day of admission ($p = 0.02$) (data not shown).