Minimally Invasive vs Open Congenital Diaphragmatic Hernia Repair: Is There a Superior Approach?

Luke R Putnam, MD, MS, Kuojen Tsao, MD, FACS, Kevin P Lally, MD, MS, FACS, Martin L Blakely, MD, MS, FACS, Tim Jancelewicz, MD, FACS, Pamela A Lally, MD, Matthew T Harting, MD, MS, FACS, for the Congenital Diaphragmatic Hernia Study Group and the Pediatric Surgery Research Collaborative

BACKGROUND: The minimally invasive surgery (MIS) approach for congenital diaphragmatic hernia (CDH) repair remains controversial. Our objective was to compare outcomes and complications of the MIS and open approaches, with risk-stratification of patients based on defect size and key patient characteristics.

STUDY DESIGN: The multinational CDH Study Group (CDHSG) registry was queried for the period from 2007 to 2015. Patient demographics and operative details, including the CDHSG Staging System defect size (A to D), were reviewed. Open cases consisted of laparotomy and thoracotomy; MIS repairs included laparoscopy and thoracoscopy. Outcomes included length of stay (LOS) for patients surviving to discharge, hernia recurrence, and adhesive small bowel obstruction (SBO) requiring surgery. Regression analyses were performed. Odds ratios (ORs) with 95% CIs were derived.

RESULTS: A total of 3,067 CDH patients underwent open (n = 2,579; 84%) or MIS (n = 488; 16%) repair. Patients undergoing open repair were more likely to be diagnosed prenatally, be premature, have lower 5-minute Apgar scores, and have major cardiac anomalies (all $p < 0.001$). Among MIS repairs, 79% were low risk (size A and B) defects vs 50% among open repairs ($p < 0.001$). Patients undergoing MIS repair experienced shorter overall median LOS, higher recurrence rates, and fewer SBO. With multivariable regression adjusting for defect size and key patient characteristics, an MIS approach was significantly associated with decreased LOS (mean −13.4 days; 95% CI −18 to −8.8 days), increased recurrences (OR 3.10; 95% CI 1.91 to 5.04), and decreased SBO (OR 0.19; 95% CI 0.06 to 0.60).

CONCLUSIONS: After risk-stratification of CDH patients, an MIS approach was independently associated with decreased LOS and SBO, but higher recurrence rates. (J Am Coll Surg 2017;224:416−424. © 2017 Published by Elsevier Inc. on behalf of the American College of Surgeons.)

Congenital diaphragmatic hernia (CDH) is a syndrome that consists of incomplete diaphragm formation, associated with pulmonary hypoplasia and pulmonary hypertension. Although patients can manifest with a wide spectrum of severity, some degree of pulmonary compromise is nearly universal. Management of this congenital anomaly consists of initial pulmonary stabilization and subsequent operative repair, followed by liberation from support and minimization of ongoing morbidity. One of the cornerstones of management, which is generally necessary for

Disclosure Information: Nothing to disclose.

Support: Center for Clinical and Translational Sciences Training Award, University of Texas McGovern Medical School (5KL2-TR000370-10).

Presented at the Southern Surgical Association 128th Annual Meeting, Palm Beach, FL, December 2016.

Received December 19, 2016; Accepted December 20, 2016.

From the Department of Pediatric Surgery, McGovern Medical School at the University of Texas Health Science Center at Houston and Children's Memorial Hermann Hospital (Putnam, Tsao, K Lally, P Lally, Harting) and the Center for Surgical Trials and Evidence-based Practice (CSTEP), University of Texas Medical School at Houston (Putnam, Tsao, K Lally, P Lally, Harting), Houston, TX; and the Departments of Pediatric Surgery, Vanderbilt University School of Medicine, Nashville, TN (Blakely) and University of Tennessee Health Science Center, Memphis, TN (Jancelewicz).

Correspondence address: Matthew T Harting, MD, MS, FACS, Department of Pediatric Surgery, McGovern Medical School at the University of Texas Health Science Center at Houston, 6431 Fannin St, MSB 5.220, Houston, TX 77030. email: matthew.t.harting@uth.tmc.edu

http://dx.doi.org/10.1016/j.jamcollsurg.2016.12.050
ISSN 1072-7515/17

Abbreviations and Acronyms

CDH = congenital diaphragmatic hernia
CDHSG = Congenital Diaphragmatic Hernia Study Group
ECMO = extracorporeal membrane oxygenation
LOS = length of stay
MIS = minimally invasive surgery
SBO = small bowel obstruction

survival, irrespective of CDH severity, is operative repair of the diaphragmatic defect.

Repair of CDH is performed using one of several approaches, which fall into 2 general categories: open and minimally invasive surgery (MIS). The most common and time-honored approach is a laparotomy, usually via a subcostal incision. The less common, alternative open approach is a thoracotomy. More recently, the MIS approach, most commonly via thoracoscopy, is being used with increasing frequency.[1] Although the thoracoscopic approach has some potential advantages, including decreased adhesion formation and enhanced recovery, comparative data are lacking. Further, previous investigation has shown that the rate of diaphragmatic hernia recurrence is higher with the MIS approach.[2]

Identification of the strengths and limitations of the open and MIS approaches to CDH repair has been limited by studies of small sample size,[3] relative infrequency of the MIS approach,[4] and a lack of stratification.[5] Recently, the CDH Study Group (CDHSG) staging system, a CDH stratification system based on diaphragmatic defect size, was developed, and its strong association with morbidity[6] and mortality[7,8] was reported. The purpose of this study was to compare outcomes and complications of the open and MIS approaches to CDH repair, with risk-stratification based on defect size and key patient characteristics.

METHODS

Study design and setting

The international Congenital Diaphragmatic Hernia Study Group (CDHSG) registry was queried for live-born neonates undergoing CDH repair from 2007 to 2015. The CDHSG is a voluntary consortium of children's hospitals committed to studying key clinical questions related to CDH through prospective data collection and analysis. Data collection forms are intermittently updated to include additional variables of interest. In 2007, the CDHSG Staging System was established. It classifies defect size by using 1 of 4 letters (A to D); "A" defects are the smallest and "D" defects are the largest (Fig. 1).[7] For the purposes of further categorization, A/B defects are small or "low-risk" defects and C/D defects are large or "high-risk." The CDHSG registry has been approved for use by the Institutional Review Board of the University of Texas McGovern Medical School at UTHealth in Houston (HSC-MS-03-223).

Outcomes

Outcomes of infants undergoing minimally invasive or open repair of the diaphragm were evaluated. The primary outcomes were survival, diaphragmatic hernia recurrence requiring an operation, adhesive disease leading to a bowel obstruction requiring an operation, and initial inpatient length of stay. These are captured on a standardized data collection form, and completed by participating centers in a prospective fashion. Patients were stratified by patient characteristics, specific interventions, and the CDHSG staging system.

Patient and operative characteristics

Patient and operative characteristics, including gestational age, birthweight, Apgar score at 5 minutes, major cardiac and chromosomal anomalies, defect side and size (A to D), surgical approach, patch use, and extracorporeal membrane oxygenation (ECMO) for patients with posterolateral defects were reviewed. Minimally invasive surgery (MIS) included laparoscopic or thoracoscopic repairs, and open approaches consisted of laparotomy or thoracotomy.

Statistical analysis

Data are described based on their distribution. Medians (interquartile range) and means ± standard deviations are reported. Binary and continuous parametric data were assessed using chi-square, Fisher's exact, or Student's *t*-tests, and continuous nonparametric data were assessed with Mann-Whitney U tests. Multivariable logistic and linear regression models were developed using a stepwise approach incorporating variables found to have values of $p < 0.2$ on univariate analysis. Missing data are described in Table 1. Statistical analyses were performed with Stata/IC 13.1 (Stata Corp LP).

RESULTS

Cohort characteristics

A total of 3,984 patients were entered into the CDHSG registry from 2007 to 2015 (a median of 394 total patients were entered annually), and 3,332 (83.7%) underwent CDH repair. Of these, 3,067 had operative approach data, underwent an operation that could be appropriately categorized as open or MIS, and, therefore, formed the total study cohort (Fig. 2). Among these