Value of Oxygenation Index in Selecting Neonates for Thoracoscopic Repair of Congenital Diaphragmatic Hernia

Mostafa Kotb[1*], Sherif Shehata[2], Sameh Shehata[1], Ahmed Khairi[1], Aliaa Rabie[1], Tamer Ghonaim[1]

[1]Department of Pediatric Surgery, Alexandria Faculty of Medicine, Alexandria, Egypt
[2] Department of Pediatric Surgery, Tanta Faculty of Medicine, Tanta, Egypt.

*Address for Corresponder: Dr. Mostafa Kotb, Department of Pediatric Surgery, Alexandria Faculty of Medicine, Alexandria, Egypt 21615. (Email: mostafa.rashad@alexmed.edu.eg)

How to cite this article:
Kotb M, Shehata SMK, Shehata S, Khairi A, Rabie A, Ghonaim T. Value of oxygenation index in selecting neonates for thoracoscopic repair of congenital diaphragmatic hernia. Iranian Journal of Pediatric Surgery 2020; 6 (1):37 -43

DOI: https://doi.org/10.22037/irjps.v6i1.31703

Abstract

Introduction: The major obstacles for routine application of thoracoscopic repair for congenital diaphragmatic hernia (CHH) in neonates include intraoperative hypercarbia, acidosis and conversion to open surgery. Therefore, strict preoperative selection criteria should be followed for successful primary thoracoscopic repair of the diaphragm and achievement of minimal conversion rate.

Materials and Methods: A prospective study was conducted from April 2016 to March 2018, where all neonates confirmed to have CDH were assessed by a specialized anaesthesia team for the possibility of undergoing thoracoscopic repair. In order to assess the severity of persistent pulmonary hypertension (PPH), oxygenation index (OI) was used and babies who had OI <5 were considered to have mild pulmonary hypertension; and consequently underwent thoracoscopic repair.

Results: Twenty nine CDH cases met the selection criteria; hence, they underwent thoracoscopic repair. Primary diaphragmatic repair was successfully performed thoracoscopically in all neonates without perioperative complication. Conversion to open repair occurred in 3 cases, with causes related to surgical factors. Recurrence was discovered in 1 case only.

Conclusion: While choosing candidates for thoracoscopic CDH repair in neonates, OI is a reliable indicator as it clarifies neonates who have good preoperative pulmonary function.

Keywords

- Congenital diaphragmatic hernia
- Oxygenation index
- Neonates
- Thoracoscopic repair

received: 25 September 2019
accepted: 02 January 2020
Published online: August 2020

Introduction

Nowadays, minimal invasive surgery (MIS) has become the gold standard in many centers for repair of CDH.[1] This is also true for late-presenting CDH cases; however, intraoperative hypercarbia, acidosis (which are due to pulmonary hypertension and other congenital anomalies associated with CDH) and conversion to open surgery are among the factors that prevent routine application of this procedure in neonates.[2] Though many reports discussed the selection criteria for successful neonatal minimally invasive CDH repair, yet they are still debatable.[3,4] In this study, we present a clinical criteria by which neonates can be safely chosen for successful minimal invasive thoracoscopic repair with a low rate of conversion to open surgery.

Materials and Methods

This prospective study was conducted from April 2016 to March 2018. All neonates with clinically and radiologically confirmed posterolateral CDH were evaluated by a specialized anaesthesia team for the possibility of thoracoscopic repair. Oxygenation index (OI) was used to evaluate the severity of persistent pulmonary hypertension (PPH) in those neonates. OI is calculated as follows: mean airway pressure MAP (in cmH_2O) × FiO_2 × 100 ÷ PaO_2 (MAP=Mean Airway Pressure, PaO_2= arterial oxygen tension in mmHg and FiO_2= fraction of inspired oxygen). Babies having an OI <5 were interpreted as having a mild degree of pulmonary hypertension reflecting a mild form of lung hypoplasia; thus, thoracoscopic repair was offered for these babies.

After adequate resuscitation of the neonates, thoracoscopy was performed via three ports: one for the thoracoscope was positioned just below the edge of the scapula, another in the fourth posterior intercostal space and the last one in the fifth intercostal space anteriorly **Figure 1**.

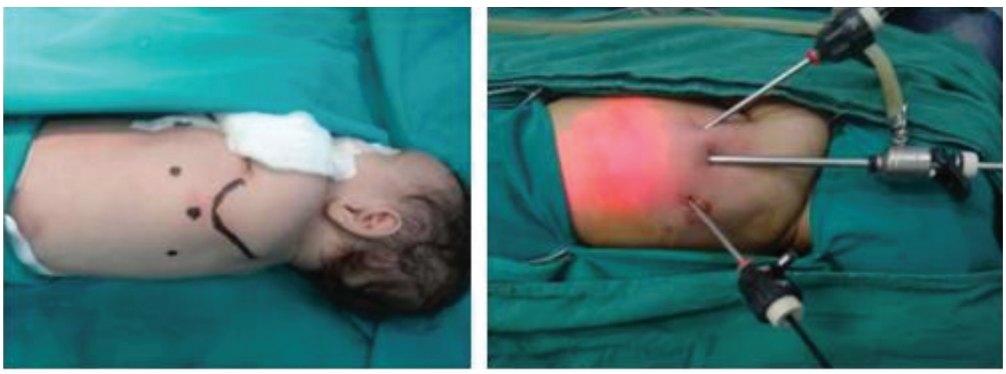

Figure 1: Ports used in the thoracoscopic repair of CDH

Carbon dioxide insufflation was kept within a low pressure (4 mm Hg) and low flow (1.5 L/min) to reduce the hernia contents back to the peritoneal cavity followed by repairing the defect using non-absorbable interrupted sutures **Figure 2**. All cases were followed in the outpatient clinic for a minimum of 6 months postoperatively.

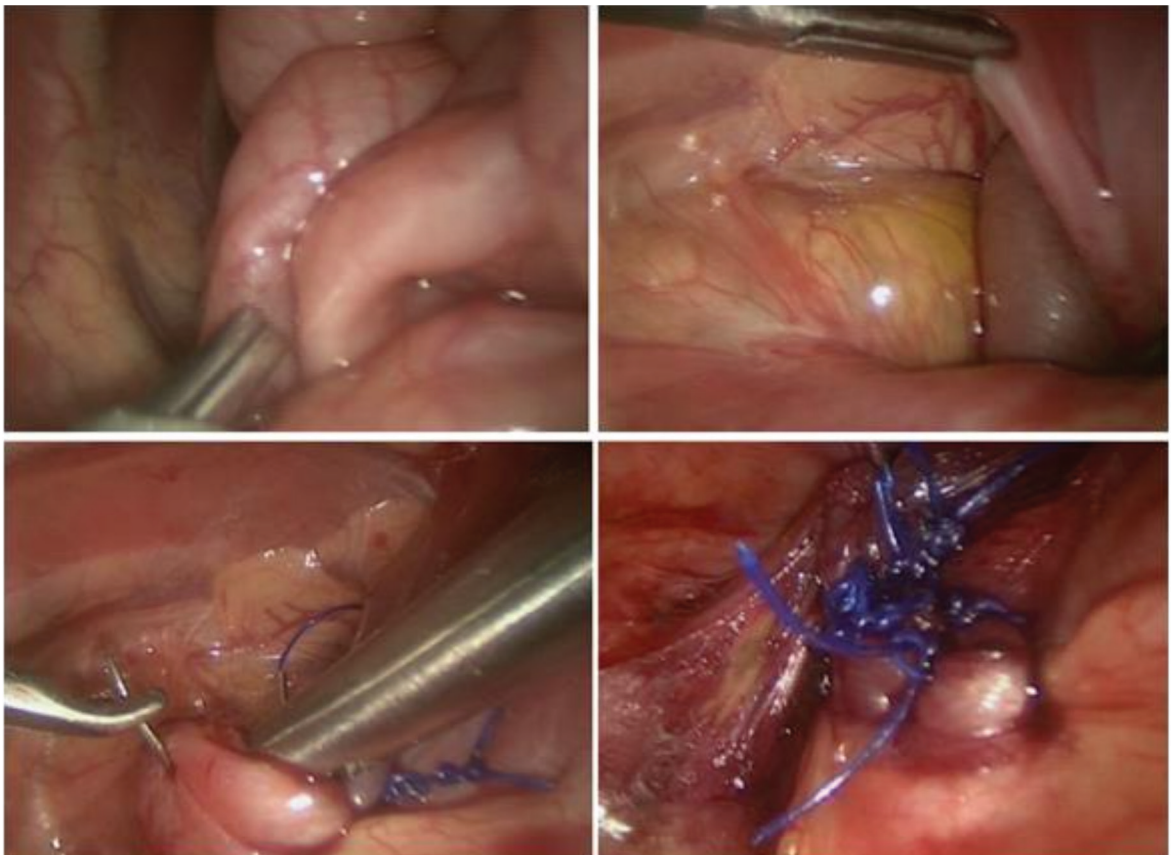

Figure 2: Repairing the defect using non-absorbable interrupted sutures

Results

Twenty nine cases out of a total of 84 cases (34.5%) of congenital diaphragmatic hernia matched the selection criteria and underwent thoracoscopic repair. Out of these cases, 24 cases were left sided (82.8%) and 6 cases were right (17.2%). Regarding gender: 19 were male (65.5%) and 10 were female (34.5%).

All of these babies were full-term with ages ranging from 1-26 days (mean 11.4 days) and their weight at operation was between 2.8-3.6 kg (mean 3.2 kg). The contents of neonatal Bochdalek hernia were reduced easily in 25 cases (86.2%), but were difficult in only 4 cases (13.8%) due to difficulty in manipulating the herniated spleen through a relatively small defect. The time needed for reduction of the hernia contents ranged from 1-36

minutes (mean 20.5 minutes), while the operative time needed for performing the thoracoscopic repair varied from 45-150 minutes (mean 81.25 minutes).

The conversion from a thoracoscopic to open repair occurred in 3 cases (10.3%). In 2 cases bleeding from a splenic capsular injury during reduction of contents along with injury of the mesentry of small intestine occurred. Whilst a large defect transmitting almost all abdominal contents into the chest with consequent difficulty in reduction; was the reason in the third case. The time needed to reach full enteral feeding ranged from 6-30 hours (mean 14 hours) while the length of hospital stay ranged from 1-4 days (mean 2.4 days). Complications occurred in 2 cases out of the 34 cases (6.9%). Splenic capsular injury while attempting to reduce the contents occurred twice. Recurrence occurred in 1 case out of 26 cases which was completed thoracoscopically (3.8%). The recurrence occurred after 6 months and was subsequently repaired by open approach through a left subcostal incision. The follow up period ranged from 6-34 months (mean 19 months).

Discussion

From the first reports of thoracoscopic repair in delayed cases of CDH,[5] this procedure became the gold standard for this age group in most centers since it was proved to be associated with faster recovery, earlier extubation, and decreased morbidity.[6] Nevertheless, two main drawbacks have limited its widespread use in neonates. First of all, high recurrence rate in comparison to open approach and secondly, intraoperative physiologic derangements resulting from CO_2 insufflations with increased brain CO_2 levels.[7] Therefore, in order to a achieve successful MIS repair, a strict patient selection criteria is necessary in the neonatal age group.[8]

Many studies reported a higher incidence of recurrence after thoracoscopic repair (5-25% compared to 0-11% with open surgery),[9] and this was attributed to the learning curve in addition to some technical factors.[10] Risk factors of recurrence are mainly defect size/prosthetic patch use and ECMO.[11] In our study, recurrence occurred in only 1 case out of 26 (3.8%). This is probably due to excluding neonates who were suspected to have a large defect preoperatively and, subsequently, will require mesh repair and those who were candidates for ECMO.

Intraoperative hypercapnia and acidosis appears to be more severe during thoracoscopy because of the lung collapse induced to prepare adequate space in the thoracic cavity in addition to CO_2 absorption from the induced pneumothorax.[12] Therefore, strict criteria should be applied to select more healthy patients, who would have adequate pulmonary reserve, so that they can tolerate the stress of the operation as well as expected compromise of pulmonary function postoperatively.[13] Yang et al [14] used a peak inspiratory pressure (PIP) of 24 mmHg as the maximum preoperative ventilatory support that a baby would need to be a candidate of thoracoscopic repair. Other proposed criteria in his study included intra-abdominal stomach and no pulmonary hypertension (PH) at the time of the operation. The criteria Yang selected seems to be appropriate since no cases required conversion,

yet in our experience, as long as the blood PH is adequately controlled, stomach herniation is not necessarily a contraindication to thoracoscopic repair.

In our study, to assess the severity of pulmonary hypertension, we used OI (Oxygenation index) as initially proposed by Gourlayet al.[15] In his study, he found that those who underwent thoracoscopic repair successfully had an average OI of 2.8; however, he intentionally chose to increase this value to 5 to use it as a selection criterion for selecting neonates for thoracoscopic repair. [15] Some authors choose OI threshold of less than 3 as a sharp cut point; thus, preferring the safe side.[16] In our study, we found a threshold value of 5, where thoracoscopy can be performed safely if the OI is <5. Hence this value is compatible with the one proposed by Gourlay *et al*.

When comparing this index to other indicators, eg. PaO_2/FiO_2 ratio, it is obvious that OI is considered a better indicator of PPHN (which is the main factor limiting primary repair by thoracoscopy), as it includes mean airway pressure (MAP), an important determinant of oxygenation. Regrettably, there are several drawbacks for the use of OI in the NICU. Firstly, it is invasive as it requires either an indwelling arterial line or arterial puncture to obtain a blood gas sample.[17] Furthermore, if blood gases are obtained, its reading is intermittent. Lastly, the site of the arterial line is the one which decides the site of sampling (e.g., only postductal gases (which may be lower than the preductal PaO_2 that perfuse the brain and heart) can be obtained if an umbilical arterial line is present. [17]

It should be noticed that the conversion to open surgery occurs in about 3.4 to 75% of the cases as a result of large diaphragmatic defects, difficulties in reducing the spleen and derangement of clinical status, such as prolonged respiratory acidosis or hemodynamic instability.[18] But in our study, since we are applying strict selection criteria, only 3 cases (10.3%) underwent conversion to open surgery. These were due to bleeding from a splenic capsular injury during reduction of contents with concomitant injury of the mesentry of small intestine in 2 cases, whilst a large defect transmitting almost all abdominal contents in the chest with consequent difficulty in reduction was noted in another case. It can be seen that all of these causes were related to surgical factors, and none of them was due to pure anaesthetic problem or general deterioration while performing the thoracoscopic repair.

Conclusion

OI is a reliable indicator in selecting neonates for primary thoracoscopic CDH repair as it indicates neonates who have good preoperative pulmonary function.

Ethical Consideration

This study is approved by the Ethics Committee of the Faculty of Medicine – Alexandria University with EC serial Protocol Number 16-00363.

Acknowledgements

Not applicable

Funding/Support

Not applicable

Conflict of interests

There is no conflict of interests.

References

1. Zhu Y, Wu Y, Pu Q, et al: Minimally invasive surgery for congenital diaphragmatic hernia: a meta-analysis. Hernia 2016;20:297-302.
2. Gomes Ferreira C, Kuhn P, Lacreuse I, et al: Congenital diaphragmatic hernia: an evaluation of risk factors for failure of thoracoscopic primary repair in neonates. J Pediatr Surg 2013;48:488-95.
3. Okazaki T, Nishimura K, Takahashi T, et al: Indications for thoracoscopic repair of congenital diaphragmatic hernia in neonates. Pediatr Surg Int 2011;27:35-8.
4. Szavay PO, Obermayr F, Maas C, et al: Perioperative outcome of patients with congenital diaphragmatic hernia undergoing open versus minimally invasive surgery. J Laparoendosc Adv Surg Tech Part A 2012;22:285-9.
5. Becmeur F, Jamali RR, Moog R, et al: Thoracoscopic treatment for delayed presentation of congenital diaphragmatic hernia in the infant. Surg Endosc 2001;15:1163-6.
6. Schlager A, Arps K, Siddharthan R, et al: Thoracoscopic Repair of Congenital Diaphragmatic Hernia After Extracorporeal Membrane Oxygenation: Feasibility and Outcomes. J Laparoendosc Adv Surg Tech Part A 2018;28:774-9.
7. Tyson AF, Sola Jr R, Arnold MR, et al: Thoracoscopic versus open congenital diaphragmatic hernia repair: single tertiary center review. J Laparoendosc Adv Surg Tech 2017;27:1209-16.
8. Fujishiro J, Ishimaru T, Sugiyama M, et al: Minimally invasive surgery for diaphragmatic diseases in neonates and infants. Surg Today 2016;46:757-63.
9. Putnam LR, Gupta V, Tsao K, et al: Factors associated with early recurrence after congenital diaphragmatic hernia repair. J Pediatr Surg 2017;52:928-32.
10. Costerus S, Zahn K, van de Ven K, et al: Thoracoscopic versus open repair of CDH in cardiovascular stable neonates. Surg Endosc 2016;30:2818-24.
11. Janssen S, Heiwegen K, van Rooij IA, et al: Factors related to long-term surgical morbidity in congenital diaphragmatic hernia survivors. J Pediatr Surg 2018;53:508-12.
12. Zani A, Lamas-Pinheiro R, Paraboschi I, et al: Intraoperative acidosis and hypercapnia during thoracoscopic repair of congenital diaphragmatic hernia and esophageal atresia/tracheoesophageal

fistula. Pediatr Anesth 2017;27:841-8.

13. Liem NT, Nhat LQ, Tuan TM, et al: Thoracoscopic repair for congenital diaphragmatic hernia: experience with 139 cases. J Laparoendosc Adv Surg Tech 2011;21:267-70.

14. Yang EY, Allmendinger N, Johnson SM, et al: Neonatal thoracoscopic repair of congenital diaphragmatic hernia: selection criteria for successful outcome. J Pediatr Surg 2005;40:1369-75.

15. Gourlay DM, Cassidy LD, Sato TT, et al: Beyond feasibility: a comparison of newborns undergoing thoracoscopic and open repair of congenital diaphragmatic hernias. J Pediatr Surg 2009;44:1702-7.

16. Ferreira CG, Kuhn P, Lacreuse I, et al: Congenital diaphragmatic hernia: an evaluation of risk factors for failure of thoracoscopic primary repair in neonates. J Pediatr Surg 2013;48:488-95.

17. Rawat M, Chandrasekharan PK, Williams A, et al: Oxygen saturation index and severity of hypoxic respiratory failure. Neonatology 2015;107:161-6.

18. Barroso C, Correia-Pinto J: Perioperative complications of congenital diaphragmatic hernia repair. Eur J Pediatr Surg 2018;28:141-7.