Pediatr Pol 2019; 94 (6): 342–346
DOI: https://doi.org/10.5114/polp.2019.92970
Submitted: 3.11.2019; Accepted: 16.12.2019; Published: 31.12.2019

PEDIATRIA Polska
PISMO POLSKIEGO TOWARZYSTWA PEDIATRYCZNEGO
Polish Journal of PAEDIATRICS
OFFICIAL JOURNAL OF POLISH SOCIETY OF PAEDIATRICS

ORIGINAL PAPER

Fast track in paediatric surgery: enhanced recovery after surgery for thoracoscopic lung resections in infants

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ABSTRACT

Introduction: Fast-track thoracic surgery is a new global perioperative management that leads to, and achieves, early recovery of the patient. Enhanced recovery after surgery (ERAS) programs represent an important clinical approach; however, these programs are not widely adapted to surgery in small children. The objective of this study was the analysis of infants and children under two years of age who had undergone an operation for congenital pulmonary malformations, regarding the possibility of fast-track thoracic surgery with the approach of ERAS programs.

Material and methods: A total of 11 children diagnosed for extra-lobar sequestration (ELS, $n = 3$), congenital pulmonary adenomatoid malformation (CPAM, $n = 2$), intra-lobar sequestration (ILS, $n = 2$), hybrid lesions (ILS + CPAM, $n = 2$; ILS + bronchial cyst, $n = 1$), or ELS with congenital diaphragmatic eventration ($n = 1$) were analysed according to the ERAS protocol.

Results: Two groups of patients were identified with differences in hospital length of stay (LOS) and the need of postoperative treatment. The median LOS was three and five days, respectively. Infants in group I had higher body weight (median: 9.9 vs. 8 kg). The complexity of the procedure (ELS removal vs. other), the length of the surgical procedure (mean operative time: 117 min vs. 190 min), use of postoperative chest tube (1 vs. 3.5 days), and the need for, or length of, Intensive Care Unit stay (median: 0 vs. 2 days) had an impact on the postoperative course and the possibility of shorter hospital stay.

Conclusions: ERAS protocol was feasible for both analysed groups of infants and small children after uncomplicated thoracoscopic surgery. Using a multidisciplinary team is a key factor to achieve success in enhanced recovery, including good compliance with the parents. Fast track in paediatric surgery results in shorter LOS and decreased stress for the child and the family.

KEY WORDS:

fast track thoracic surgery, enhanced recovery after surgery, ERAS, infants, thoracoscopy.

INTRODUCTION

Fast-track thoracic surgery is a new global perioperative management that leads to, and achieves, early recovery of the patient. This approach has many important implications for the patients and parents/guardians, as well for the health service, due to reduction of costs of the patients' hospital stay [1]. Enhanced recovery after surgery (ERAS) programs are an important clinical pathway for both efficiency of care and surgical outcomes [2]. Never-

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theless, these programs are not widely adapted to surgery in small children. ERAS protocols are gaining acceptance also among paediatric surgeons. Many of the methodological considerations for the introduction of a fast track are parallel to those used in thoracoscopic procedures in the treatment of congenital pulmonary malformations.

AIM OF THE STUDY

With the confirmed safety of endoscopic lung resection procedures in infants and the need for safety rules after lung resections, a group of children under two years of age, undergoing thoracoscopic procedures with lung resections, was retrospectively analysed. The objective of this paper was the analysis of the possibility of introduction of the ERAS protocol, and the analysis of positive and negative factors affecting the introduction of enhanced recovery protocol in very young children.

MATERIAL AND METHODS

DESIGN OF THE STUDY

The medical records of infants under two years of age, who underwent operation between 2013 and 2016 for a congenital pulmonary adenomatoid malformation (CPAM), intra-lobar sequestration (ILS), or extra-lobar sequestration (ELS), were retrospectively reviewed.

SURGICAL PROCEDURE

All cases were operated on by a single paediatric surgeon experienced in newborn and infant thoracic surgery. Operative treatment was performed under general anaesthesia. The patient was positioned in the lateral decubitus position without the need for single lung ventilation. Working pressure of insufflated CO_2 was initially 8 mm Hg, usually lowered to 6 mm Hg after lung collapse was obtained. The three-port technique was used: usually a 5 mm port for the camera and a 5 mm for the right-hand Haemo-Lock clip applicator, with reduction to 3 mm for other instruments, and the last 3 mm port for the left-hand instruments. In the first step, the pathology was visualised and the planned extent of resection was confirmed. In the case of lobectomy, an anatomic resection of the lobe was performed. After the preparation vessels and bronchus were double clipped and divided. For the lung parenchyma transsection and ligament release we used a BiClamp device (Erbe Elektromedizin, GmbH, Tubingen, Germany). In the case of lung-sparing surgery (segmentectomy) in ILS we used one of the two available techniques: either primary ligation of arterial feeding vessels with subsequent resection of ischaemic lung parenchyma or in the case of primary good delineation of hyperaemic lung parenchyma, resection was started from the peripheral parenchyma with subsequent clipping of feeding vessels. In the case of ELS, sequestrectomy was performed after all vessels were separately clipped and divided. In each case the specimen was brought out with a typical endoscopic extraction bag through the slightly enlarged posterior trocar site. A chest tube was typically inserted through the anterior lower port side.

ENHANCED RECOVERY AFTER SURGERY PROTOCOL

For the purpose of this retrospective analysis of children undergoing lung resection for congenital pulmonary malformation, the modified fast-track protocol of Clermidi *et al.* was used [1] (Table 1). The modification was based on the different objective of the protocol, because in the above-mentioned fast-track protocol it involved a one-day hospital stay.

RESULTS

DEMOGRAPHICS

Out of 46 newborns and infants qualified for thoracoscopic procedures, 11 were the subject of further analysis, including seven girls and four boys. The other 35 thoracoscopic procedures were performed for 30 patients with oesophageal atresia with tracheoesophageal fistula (EA + TEF) and with five congenital diaphragmatic hernia surgeries (CDH). Median age during surgery was eight months (range: 4–21). The median day of discharge in the entire group was five days (range: 3–8). Indications for surgery were as follows: ELS (n = 4), CPAM (n = 1), ILS (n = 2), and hybrid lesions, n = 4 (ILS + CPAM, n = 2; ILS + bronchial cyst, n = 1; ELS with congenital diaphragmatic eventration, n = 1). Analysis of clinical factors included pre- and peri-operative management procedures, the use of opioids, length of postoperative pleural drainage, and complications.

SURGICAL PROCEDURES

Surgical procedures included: right lower lobectomy (RLL, n = 2), right middle lobectomy (RML, n = 1), excision of ELS (n = 4), and lung-sparing surgery (LSS) – segmentectomies (n = 4). In one case of ELS excision simultaneously an oesophageal hiatus plasty was performed. During the right middle lobectomy, we additionally resected a bronchogenic cyst.

In eight patients the pathology was diagnosed prenatally at a median gestational age of 22 weeks. In three patients it was an incidental finding during diagnostic studies of comorbidities: eventration of the diaphragm after congenital diaphragmatic hernia closure through laparotomy, suspicion of oesophageal duplication, or pneumonia accompanying systemic infection. The median age at the time of operation was 7.4 months (range:

TABLE 1. Enhanced recovery after surgery (ERAS) protocol

1. Objective of hospital stay
• Up to 3-day hospital stay for children undergoing lobectomy, wedge resection, or sequestrectomy
2. Pre-operative selection of patients
• Planning surgery at an optimal age of at least 4 months (even in the case of prenatal diagnosis, if possible) due to anticipated easier procedure and quicker recovery • Planning the surgery and postoperative management with patients' parents, and counselling for expected hospital stay, indicating criteria for hospital discharge • Family counselling for postoperative home care • Analysis of distance from the patient's home to the hospital • Preoperative medical evaluation focused on respiratory tract: absence of rhinitis, bronchitis, cough, or fever in the past seven days prior to surgery is mandatory
3. Exclusion criteria
• Neonatal respiratory distress symptoms requiring mechanical ventilation • Congenital lobar emphysema • Infection of respiratory tract (rhinitis, bronchitis, cough, or fever) within one week prior to qualification for surgery • Any other surgical problems or difficulties
4. Intra-operative evaluation and management
• Adequate control of temperature (with thermal blanket) • Adjusted body hydration • Controlled risk of bleeding • Controlled risk of air leakage • Optimal pleural drainage • Multimodal analgesia including systematic use of infiltration of each trocar site with local anaesthetics (lidocaine and bupivacaine) at the end of the procedure • Beginning of postoperative analgesic therapy before the end of surgical treatment
5. Post-operative management
• Removal of nasogastric tube prior removal of tracheal intubation • Removal of intubation while in the operating room • Postoperative care in the recovery room, routine use of anti-emetics • Analgesic management • Respiratory physiotherapy if required • Initiation of oral nutrition after two hours • Removal of intravenous access when pain control and oral alimentation tolerance is reached • In case of pleural drainage: removal on first postoperative day or until pleural exudate or air leakage resolves
6. Hospital discharge criteria
• Full consciousness • Stable cardiopulmonary status • Good pulmonary ventilation including normal oxygen saturation and no tachypnoea • No vomiting • Pain control with oral non-opioid analgesics • Chest radiograph: minimal pleural effusion or minimal pneumothorax is accepted after the chest tube removal • Availability for phone call in case of unusual symptoms

ERAS protocol according to [1], modified

3–13 months). While awaiting operation, all patients were closely monitored in an outpatient clinic; none developed serious respiratory symptoms. The median operative time was 140 minutes (range: 55–210). Operative time was the shortest for ELS cases with a median of 110 minutes (range: 60–190), and the longest for hybrid lesions with a median of 205 minutes (range: 200–235). There were no major perioperative complications.

The infants were discharged within a median of five days (range: 3–8 days). During the follow-up period there were no cases of remnant lesions; one patient developed mild upper respiratory tract infection within three weeks of the operation.

POSSIBLE FACTORS CONTRIBUTING TO ERAS

Two groups of patients were identified with differences in length of stay (LOS) and the need of postoperative treatment (group I, patients 1–4; group II, patients 5–11, Table 2). In group I the median postoperative LOS was three days, and in the second group the mean LOS was five days. Infants in group I were at the same age as children in group II (median: 8.5 vs. 8 months) and had higher body weight during the surgery (median: 9.9 vs. 8 kg). The complexity of the procedure (ELS removal vs. other), the length of the surgical procedure (median operative time: 117 min vs. 190 min), as well as the need or length of ICU stay (median: 0 vs. 2 days) had an impact on the postoperative course and the possibility of shorter hospital stay. The median length of the postoperative chest tube use was shorter in group I: 1 vs. 4 days.

Additional factors contributing to longer LOS included the need for re-intubation ($n = 1$), intraoperative bleeding requiring catecholamines ($n = 1$), and the need of concomitant diaphragmatic plication ($n = 1$). Analysis of potential candidates for earlier discharge from group II revealed that despite more advanced procedures, such as segmentectomy of 9/10 ($n = 3$) and right middle lobectomy (RML) ($n = 1$), the only reason for prolonged hospitalisation was exudation requiring pleural drainage and the necessity of its assessment.

DISCUSSION

ERAS protocols in the paediatric surgery setting are being developed in various conditions. There are already existing reports about appendicitis [3], elective colorectal surgery [4], and paediatric cardiac surgery [5]. Preliminary outcomes indicate decreased complication rates, lower mortality, and shorter hospital length of stay. Some authors have noted already that benefits from ERAS protocols could be extended to neonates and small babies [6, 7].

The clear benefits of a thoracoscopic approach in the treatment of pulmonary lesions in children resulting in less morbidity connected with thoracotomy including

TABLE 2. Patients' characteristics and treatment

Patient	Primary clinical disease	His-pat	Hbd	When diagnosed (Hbd)	Patient comorbidities	Localization	Age at surgery (months)	Time of surgery (min)	ICU	Length of stay in ICU (days)	Days of thoracic drainage	Day of discharge	Surgical procedure	Drainage
1	CPAM type II	CPAM	38	17	ASD II, PFO	Right lung, inferior lobe	14	160	0	0	1	3	LLL	1
2	ELS	ELS	39	24	No	Left lung, segment 10; artery from abdominal aorta	6	60	0	0	1	3	ELS resection	1
3	ELS	ELS	38	35	ASD II, PDA	Right lung, segment 8; narrow arteria from celiac trunk	7	160	1	1	1	3	ELS resection	1
4	Subdiaphragmatic ELS	ELS	40	29	Neonatal exanthema	ELS subdiaphragmatic	10	75	0	0	0	3	ELS resection, oesophageal hiatus plasty	0
5	ELS, recurrent relaxation of diaphragm	ELS	38	6 months postnatally	Congenital diaphragmatic hernia, Nissen fundoplication, recurrent relaxation of diaphragm	Below inferior lobe, right lung	21	190	0	0	2	8	ELS resection	1
6	ELS	ELS	35	22	ASD II, PFO, hypospadiasia, sacral sinus, IVH I, RDS I	Left lung, segment 9/10	7	110	0	0	0	5	LSS – 9/10 segmentectomy, plication of the diaphragm	0
7	ILS	ILS	40	3 months postnatally	ASD II, pneumonia	Left lung, segment 9/10	4	175	1	2	1	5	LSS – 9/10 segmentectomy,	1
8	ILS	ILS	38	prenatally (no details)	NEC, deep vein thrombosis	Left lung, segment 10	8	155	0	0	3	5	LSS – 10 segmentectomy,	1
9	CPAM type II + ILS	CPAM + ILS	40	21	PDA, tricuspid insufficiency	Right lung, segment 10	8	235	1	4	4	7	RLL	1
10	CPAM type I	CPAM + bronchogenic cyst	40	23	ASD II, susp. of oesophageal duplication	Right lung, medium lobe	8	205	1	3	4	5	RML, resection of the cyst	1
11	CPAM type II + ILS	CPAM + ILS	38	22	ASD II, mild pulmonary hypertension	Left lung, segment 9/10; CPAM segment 8	6	200	1	3	4	7	LSS – 9/10, 8 segments resection	1

ELS – extra-lobar sequestration, CPAM – congenital pulmonary malformation type II, ILS – intra-lobar sequestration, LLL – left lower lobectomy, RLL – right lower lobectomy, RML – right middle lobectomy, LSS – lung-sparing surgery, ASD – atrial septal defect, PFO – persistent foramen ovale, PDA – patent ductus arteriosus, NEC – necrotic enterocolitis, IHV – intraventricular haemorrhage, RDS – respiratory distress syndrome, ICU – intensive care unit, Hbd – habdomen (week of pregnancy)

lower risk of scoliosis, chest wall deformity and muscle girdle weakness, eagerness of reduction of pain, faster recovery, and reduction of long term morbidity of thoracic surgery have contributed to its current wider application.

In this analysis a hypothesis was proposed regarding the possibility of introduction of the ERAS protocol in infants and children up to two years of age. A detailed analysis of patients treated for congenital pulmonary malformations, including CPAM and ILS or ELS, was performed. In the entire cohort of children thoracoscopy was applied, and in all of them early recovery was possible. An analysis of factors positively and negatively affecting the introduction of ERAS protocol in these very young children was also performed.

Due to the age of patients and diagnoses of congenital pulmonary malformations, this group forms a unique entity. No statistical analysis could be performed for these groups; however, it was possible to determine patients for whom very early hospital discharge was feasible.

With the implementation of a number of clinical decisions, it was possible to follow the ERAS strategy [1, 8] in the analysed group of small children. Qualification to elective surgical procedure was based on good nutritional patient status, parental approval for co-operation with respect to post-operative out-patient care, alert procedures while being at home, and easy access to a hospital. No surgical problems appeared during operation. Adequate optimal hydration and intra-operative multimodal pain management including local administration of analgesic were mandatory. Post-operative management included early removal of the nasogastric tube followed by removal of tracheal intubation, performed in the operating room. It was important to begin oral nutrition within two hours of the surgery, as well as the removal of pulmonary drainage if no complications were present. Hospital discharge criteria were based on good respiratory and circulatory function, no vomiting, sufficient pain control, and no pathological or minimal pulmonary symptoms in chest X-ray.

This study was focused on the application of the ERAS strategy of management as the entire system of patient care. Observations performed so far indicate that each part of this system, including the surgeon, anaesthesiologist, nurse, and supporting parents, are necessary to allow the implementation of the approach of ERAS protocol. It confirms the thesis that the status of the respiratory system is a critical issue facilitating the advancement of children along ERAS recently reported by other authors [9].

In conclusion, the ERAS protocol is feasible for uncomplicated thoracoscopic surgery also in infants and small children. The need for prolonged pleural cavity drainage, increased length of mechanical ventilation, and the risk of postoperative atelectasis or pneumonia are factors determining the need of longer hospital stay. Multidisciplinary teamwork is mandatory to achieve a good success rate in enhanced recovery; good compliance with the parents is also mandatory. This could result in shorter length of hospital stay, lower invasiveness of hospitality for the child, and low rate of morbidity. Fast-track surgery creates a new approach in the management of paediatric patients.

DISCLOSURE

The author declares no conflict of interest.

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