

COMPARATIVE ANALYSIS OF MODIFIED RAVITCH AND MINIMAL INVASIVE NUSS PROCEDURES FOR THE CORRECTION OF PECTUS EXCAVATUM IN CHILDREN

ES Boia¹, MC Popoiu¹, VL David², A Nicodin³, G Cozma³, O Adam², Maria Trailescu⁴, T Kovacs⁵, T Milassin⁵, S Tornyos⁵

¹University of Medicine and Pharmacy “Victor Babes” Timisoara, Romania, Department of Pediatric Surgery and Orthopedics

²Emergency Children’s Hospital “Louis Turcanu” Timisoara, Romania, Department of Pediatric Surgery and Orthopedics

³University of Medicine and Pharmacy “Victor Babes” Timisoara, Romania, Department of Thoracic Surgery

⁴County Hospital Arad. Romania, Department of Pediatric Surgery and Orthopedics

⁵Pediatric Surgery Unit, Pediatrics Clinic, University Hospital Szeged, Hungary

Abstract

Pectus excavatum (PE) is the most frequent anterior chest deformity. Despite that since now more than 50 surgical procedures were performed for the correction of PE, only two were widely accepted by the medical community and each one of them was considered, in its own period of time, the gold standard in the surgical treatment of PE. This study is a retrospective comparison of the outcomes of the two main surgical procedures for the correction of PE, modified Ravitch procedure (MRP) and minimal invasive Nuss procedure (MIRPE) in The Department of Pediatric Surgery and Orthopedics, Emergency Children’s Hospital „Louis Turcanu”, Timisoara, Romania and in The Pediatric Surgery Unit, Pediatrics Clinic, University Hospital Szeged Hungary in the last 10 years. A total of 39 cases of children underwent surgical correction of pectus excavatum, 29 by MRP, mean age 9 years and 10 by MIRPE, mean age 13 years. There were no deaths in any group. Mean hospital stay was 13 days for the MRP group and 9 days for the MIRPE group. Mean intraoperative blood loss was 180 ml for MRP and 55 ml for MIRPE. Complications occurred in 19 patients operated by MRP and 3 by MIRPE. The therapeutic and the esthetic results were considered favorable in both MRP and MIRPE groups. In conclusion there are several advantages of MIRPE: hospital stay is shorter, less intraoperative blood loss, fewer and less severe complications, less recurrences and the reintervention. All of this with better cosmetic results.

Key words: pectus excavatum, Ravitch, Nuss, comparison

Introduction

Pectus excavatum (PE) is the most frequent anterior chest deformity occurring in approximately 1 in 1000 live births (1). The first surgical interventions for the correction of PE were performed by Meyer and Sauerbruch in 1911 and 1913 (2, 3). Despite that since now more than 50 surgical procedures were performed for the correction of PE, only two were widely accepted by the medical community

and each one of them was considered, in its own period of time, the gold standard in the surgical treatment of PE (4).

The surgical procedure proposed by M. Ravitch in 1949 remained for almost 5 decades the most important therapeutic method for PE. The surgical technique consists in the excision of the deformed costal cartilages, transverse osteotomy of the sternum and stabilizing the chest wall in normal position (5). The technique was later improved by introducing a substernal metal bar (6). Despite that many modification of the technique were made during time, the main principles of the operation remained the same: to remove the deformed costal cartilages and stabilize the sternum in normal position. An improved version of this technique was performed in over 50 cases, with excellent results, by Prof. Univ. V. Fufezan in Department of Pediatric Surgery and Orthopedics, Emergency Children’s Hospital „Louis Turcanu”, Timisoara, Romania. (7)

In 1998 Donald Nuss reported his 10 year experience with a minimal invasive surgical repair of PE (MIRPE). The principle of the technique consists in applying a force over the sternum from behind forcing it to advance in normal position. This is achieved by inserting a convex steel bar under the sternum through small bilateral thoracic incisions. The steel bar is inserted with the convexity facing posterior, and when it is in position, the bar is turned over in order to correct the deformity (8). No cartilage resection and no sternotomy are necessary (8). In the late decade a whole sort of improvements were added including the routine use of thoracoscopy and the development of a lateral stabilizer (9). Long term favorable outcomes (95%) led to its wide adoption replacing gradually the Ravitch technique (9).

This paper is a comparative analysis of the outcomes of the two main surgical procedures for the correction of PE, modified Ravitch procedure (MRP) and MIRPE. The study was carry out in The Department of Pediatric Surgery and Orthopedics, Emergency Children’s Hospital „Louis Turcanu”, Timisoara, Romania and in The Pediatric Surgery

Unit, Pediatrics Clinic, University Hospital Szeged, Hungary.

Material and Methods

This study is a retrospective comparison of all patients undergoing PE repairs using MRP and MIRPE, during the period of time between January 2000 and January 2010, in both clinics mentioned above. We reviewed patient’s charts, surgical procedures registry, X-rays, photographic images, CT’s and other imagistic evaluation recordings. We analyzed data regarding age, sex, demographics, new case/ recidives, evaluation protocol, surgical procedure and outcomes of the therapy.

Results

A total of 39 cases of children underwent surgical procedures for pectus excavatum repair. Male to female ratio was 4: 1. Age of the patients at the time of the surgical procedures ranged between 13 moths and 18 years, mean 11 years. Most of the patients were in the age group 10- 16 years, 10 in the group 5- 10 years, 6 were over 16 years and 3 were between 1 and 5 years old (Fig. 1). The youngest patient operated was a 13 months old boy with sever cardiac impairment due to sternal compression.

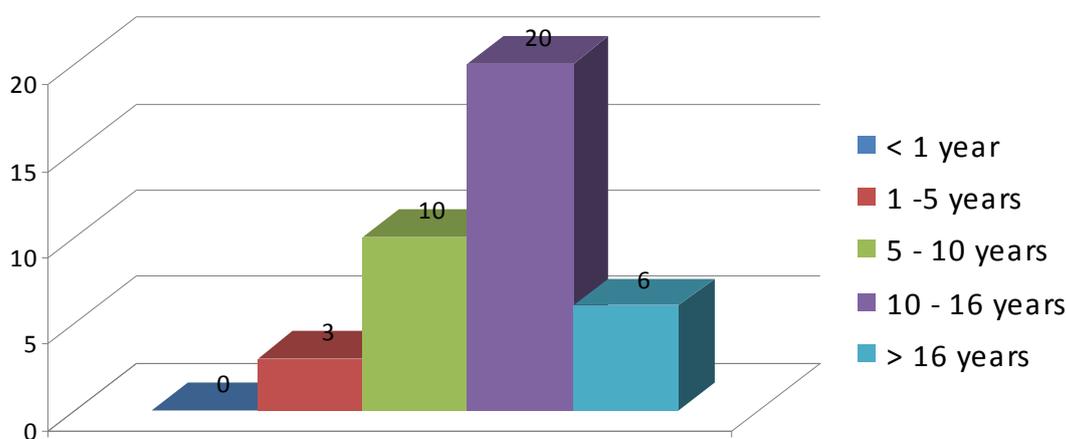


Fig. 1. The age of the patients.

The surgical correction of the deformity was performed in 29 cases, mean age 9 years, by MRP and in 10 cases, means age 13 years, by MIRPE. Only two of the MIRPE group patients were younger than 10 years old. Both MRP and MIRPE together with our modifications of both surgical techniques were previously presented and is not the subject of this paper (10, 11).

In 3 there was a complex morphology of the deformity, including both protrusion and depression of the sternum. In three cases the deformity was recurrent after a previous repair. In all of these cases, a girl 15 years old and

2 boys 15 and 17 years old, the primary correction was made by MRP and was performed at the age of 5, 8 and 13.

Mean hospital stay was 13 days for the MRP group and 9 days for the MIRPE group. Mean blood loss was 360 ml in the MRP group and 55 ml in the MIRPE group. In 4 patients postoperative blood transfusion was necessary. The bar was removed after a mean period of 13 months for the MRP group and 36 months for the MIRPE group. For 8 patients, 4 MRP and 4 MIRPE the bar was not removed yet. The main parameters compared are presented in Table 1.

Table 1. Main parameters compared.

	MRP	MIRPE
Number of cases	29	10
Age	9 (13moths – 17 years)	13 (8 – 15 years)
Mean hospital stay	13 days (7 – 26 days)	8 days (6 – 11 days)
Blood loss	180 ml	55ml
Early complications	21	0
Late complications	7	3
Nonelective bar removal	1	0
Recurrences	3	0
Reoperation	4	1

No major intraoperative accidents and no deaths occurred in none groups. Early complications occurred in 16

patients operated by MRP and none operated by MIRPE technique (Table 2).

Table 2. Early complications.

	MRP	MIRPE
Number of patients	16	0
Pneumothorax	10	0
Wound dehiscence	4	0
Pleural effusion	3	0
Hemothorax	2	0
Pleuresy	1	0
Pulmonary contusion	1	0
Total	21	0

Late complications occurred in 6 patients, 3 from each group. There were a total of 7 complications for the MRP: 3 bar mobilizations, 1 cheloid, 1 pleuresy, 1 pericarditis and a cheloid. The most severe complication occurred in a 9 years old boy. One year after the operation the bar mobilized and migrated by erosion in the pericardial cavity producing pericarditis and massive pericardial

effusion. Emergency surgical intervention and removal of the bar was necessary. For MIRPE patients there was a late pleural effusion, a pleuresy and a wound dehiscence. Reintervention was necessary for 5 patients, 3 for reattaching the bar, all in the MRP group and 2 for closing the wound dehiscence, one for each group.

Table 3. Late complications.

	MRP	MIRPE
Number of patients	3	3
Bar mobilization	3	0
Pericarditis	1	0
Pleuresy	1	1
Pleural effusion	0	1
Wound dehiscence	1	1
Cheloid	1	0
Total	7	3

In total complications occurred in 19 patients operated by MRP and 3 by MIRPE. The therapeutic and the

esthetic results were considered favorable in both MRP and MIRPE groups (Fig. 2, Fig. 3)

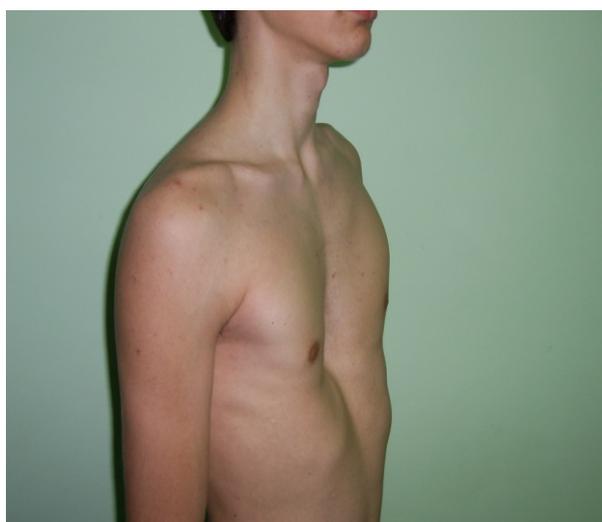


Fig. 2. Pre- and postoperative aspect, MRP, 17 years old patient.



Fig. 3. Pre- and postoperative aspect, MIRPE, 16 years old patient.

Discussions

Since the introduction of the minimal invasive Nuss technique for the correction of PE in the late 90's there is an intense debate over the advantages and disadvantages of this technique over the classical Ravitch procedure. Both procedures are widely spread over the world with multiple variations regarding the surgical technique, age of the operations, length of hospital stay and other parameters. This could be a potentially source of errors when carry out a multicentre comparative study. This is not the case of our study because, despite the fact that this study was made in two different pediatric surgery departments in two different countries, both types of operations were performed in both clinics and the majority of them were performed by the same teams of surgeons.

It is now widely recognized that age of the patient is one of the main factors influencing the outcomes of surgery. The latest recommendations in the medical literature indicates that for optimal results, regardless of the surgical procedure, the patient should be at the time of the operations just before puberty when the rib cage is still malleable enough and the bar remains inside the thorax during the pubertal growth spurt (9, 12). In our series the MRP group had a median age of 9 years with limits between 13 months and 17 years. This fact is mainly due to the fact that in the early years comprised in this study, when most of the MRP were performed, according with the literature of the time there was the believe among surgeons that the optimal age for operation is between 6 and 10 years. The youngest patient operated was 13 years old for which the indication of

the operation was made upon the presence of severe cardiac impairment. In fact only 3 of the patients were beyond the age of 5 at the time of surgery, all of them in the MRP group. In the MIRPE group the mean age of the patients was 13 years. Only two of them were beyond the age of 10, an 8 years old girl and 9 years old boy, but the risk of recidives can be overcome by leaving the bar inside the thorax for a longer period.

In 3 patients the disease was recurrent after previous MRP. The initial operation was performed at the age of 5, 8 and 13. While in the first two cases the small age of the patients at the initial operation is the most obvious cause, in the third case this is no longer valid. This last case was first operated in another services and we don't have sufficient data about it, but the fact that the period between the initial operation and the recurrence is relatively small (4 years), is an indication that the most probably cause is a precocious surgical technique during the initial operation. Anyway the main cause for recurrence remains the two early correction of the chest deformity.

Previous reports indicated a longer hospital stay for the patients operated by MIRPE (13). In our series the mean hospital stay was longer for the MRP group 13 vs. 8 days. The reason for this is that in patient operate by MRP we considered necessary at least 7 days of parenteral antibiotics, the patients needs special attention because of the amount of tissue damage during the operation and because the wound has serious proportion. The maximal hospital stay was in 7 years boy from the MRP group in which wound infection and dehiscence occurred. Perhaps in more rich countries

with better transport infrastructure and better medical education in the general population, there is the possibility of managing this patients ambulatory, but in our country the reality is that in only a minor number of cases the patients can be released from the hospital previous than to the removal of the wound stitches (10-14th day). In the MIRPE group the main factor influencing the hospital stay is the postoperative pain and the need for epidural catheter analgesia. In our cases this was rarely needed more than 3 days so the mean hospital stay of 9 days is caused mostly by a more precocious approach characteristic of the early phases of the learning curve. Blood loss was higher for the MRP group, for of the patient from this group necessitating a postoperative blood transfusion. This seems logical for us thinking that the MRP involve a longer skin incision, section of the pectoral muscles, excisions of the costal cartilages and sometime osteotomy of the sternum (7), despite that other reports had different results (13).

Despite that the therapeutic and the esthetic results were considered favorable by the majority of the patients from both groups, by placing the incisions in less visible location, the cosmetic advantages of the MIRPE are obvious. In contradiction with the previous reports which indicated fewer complications for the MRP than for MIRPE, in our series the most frequent and the most severe complications occurred in patients operated by MRP, 65% vs. 30% (13). Pneumothorax occurred in almost 30% of the patients in the MRP group and in none of the patients in the MIRPE group. This is in contradiction with the medical literature that indicates a rate of 2% for the MRP and 3.6% for the MIRPE. There are two main reasons for this: First is that despite that during MRP it is preferred not to enter the pleural cavity, in many cases this is impossible due to the intimate contact between the pleura and the posterior aspect of the chest wall; the second reasons is that in the variation of the MIRPE performed by us instead of insufflating CO₂ in the pleural cavity we induced the pneumothorax at the start of operation in order to create the spaces necessary for the operation (11). After the operation we routinely drained the pleural cavity for a few days avoiding in this manner the accumulation of air inside the pleural cavity. One of the most common complications for the MRP is wound infection (14). In our series wound infection and dehiscence occurred in 4 (13%) of the MRP patients altering the

esthetic results and prolonging the hospital stay. This complication did not occur in the MIRPE patients. The reason for this is that compared to the MIRPE in MRP the incision of the skin is significantly higher and stabilizing the sternum in normal position induces great tension in the skin and in the underlying tissue. Other complications like hemothorax, early pleural effusion, pleurisy occurred only in the MRP patients and are the expression of higher trauma over the chest wall during the operation. Skin erosion and exteriorization of the bar without previous infection occurred in two case, one for each group. This is a common complication for metallic implants and is due to the fact that the end of the implant is too close to the surface and friction forces damage the skin.

One of the most severe complications of the surgical intervention for PE is the mobilization and the migration of the bar. In the past this complication occurred in as high as 15% of the cases for MIRPE (15). Nowadays the rate of this dropped to 1% after lateral stabilizers were introduced (9). For MRP this complication is very rare, mainly in the latest two decades (16). Contrary to the expectations in our series migration of the bar occurred only in the MRP group. In two of the cases the migration was minimal and reintervention with the suture of the bar resolved the problem. In the third case the bar eroded the pericardium putting in real danger the life of the patients. This was the most severe complication in our series and is an indication of how important is to firmly secure the bar to the chest wall. After that we learned our lessons and always secured tightly the bar and for the MIRPE patients we always used bar stabilizers.

Conclusions

1. The age of the patient is an important factor for the outcome of the surgical correction, 2 of the 3 recurrences in our series being operated before the age of 10.
2. Hospital stay is shorter for the MIRPE patients
3. Intraoperative blood loss was greater for the MRP than MIRPE patients.
4. MIRPE has fewer and less severe complications
5. The recurrences and the need for reintervention is lower for MIRPE than MRP
6. All of this with better cosmetic results

References

1. Kelly RE, Lawson ML, Paidas CN et al. Pectus excavatum in a 112-years autopsy series: anatomic findings and the effect on survival. *J Pediatr Surg* 2005;40:1275-8
2. Meyer L: *Zurchirurgischen Behandlung der angeborenen Trichterbrust*. *Verh Bel Med Gest* 42:364, 1911.
3. Sauerbruch F. *Die Chirurgie Der Brustorgane*, Vol. 1. Berlin: Julius Springer, 1920:437.
4. Rădulescu A, Adam O, Boia ES, Popoiu MC. *Pectus excavatum. Diagnostic și tratament*. România, Timișoara: Artpress 2005
5. Ravitch MM. The operative treatment of pectus excavatum. *Ann Surg*. 1949;129:429-44
6. Adkins PC, Blades BA. Stainless steel strut for correction of pectus excavatum. *Surg Gynecol Obstet*. 1961;113:111-3
7. Fufezan V, Tepeneu P. A simplified surgical procedure for the correction of pectus excavatum. *Timisoara Medicala*. 1986;31:S62-DS67
8. Nuss D, Kelly RE Jr, Croitoru DP, Katz ME. A 10-year review of a minimally invasive technique for the correction of pectus excavatum. *J Pediatr Surg*. 1998 Apr;33(4):545-52.

9. Nuss D. Minimally invasive surgical repair of pectus excavatum. *Semin Pediatr Surg.* 2008 Aug;17(3):209-17
10. David VL, Puiu M, Boia ES, Popoiu MC. Anterior chest deformities therapy in children. *Timișoara Medical Journal* 2008: Vol 58, Supplement No. 2, p 286-289
11. Nicodin A, Boia ES, Popoiu MC, Cozma G, Nicodin G, Badeti R, Trailescu M, Adam O, David VL. Preliminary results after Nuss procedure. *Chirurgia;* (2010) 105: 203-210, Nr. 2, Martie – Aprilie, p 203-210
12. Humphreys GH 2nd, Jaretzki A 3rd. Operative correction of pectus excavatum. *J Pediatr Surg.* 1974 Dec;9(6):899-909.
13. Fonkalsrud EW, Beanes S, Hebra A, Adamson W, Tagge E. Comparison of minimally invasive and modified Ravitch pectus excavatum repair. *J Pediatr Surg.* 2002 Mar;37(3):413-7.
14. Boehm RA, Muensterer OJ, Till H. Comparing minimally invasive funnel chest repair versus the conventional technique: an outcome analysis in children. *Plast Reconstr Surg.* 2004 Sep 1;114(3):668-73; discussion 674-5.
15. Park HJ, Lee SY, Lee CS. Complications associated with the Nuss procedure: analysis of risk factors and suggested measures for prevention of complications. *J Pediatr Surg.* 2004 Mar;39(3):391-5; discussion 391-5.
16. Kelly RE Jr. Pectus excavatum: historical background, clinical picture, preoperative evaluation and criteria for operation. *Semin Pediatr Surg.* 2008 Aug;17(3):181-93

Correspondence to:

Eugen Boia
Gospodarilor Street, No. 42,
Timisoara 300778,
Romania
E-mail: boiaeugen@yahoo.com