

Peer review file

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Reviewer A

Comment 1: In the study, the authors present their experience in surgical treatment of pectus excavatum using locking plates. The article emphasizes the important, but also difficult issues in clinical practice, concerning surgical treatment of congenital deformities of the chest. However, surgical treatment of congenital deformities, is a challenging for the surgeon especially in adult patients. The most important condition to obtain a satisfactory results of treatment is stable and reliable sternal and costal stabilization. Despite of the minimally invasive Nuss method, Ravitch procedure still finds application in the surgical treatment of advanced deformities, especially in patients whose chest is not suitable for modifications. Moreover the Ravitch procedure is invasive, and is also charged with a relatively high rate of relapses. As the authors wrote, many different methods have been developed to stabilize the corrected chest. In my surgical practice, I combine the Ravitch method and the Nuss procedure, which helps to achieve chest stabilization by introducing a Nuss bar, having a good and lasting correction effect. The way of sternal stabilization chosen by the authors also deserves attention. However, the use of locking plates is not new and has been used especially in cases of post-traumatic rib stabilization.

The corrective procedures in 70 years old patient is slightly unusual. Could the authors explain the indications for those patients?

Reply 1: Thank you very much for your comments. Indeed, symptomatic pectus excavatum in senior patients is an underestimated problem. Most of these patients are referred with cardiovascular complaints at an older age, while the severity of their pectus was misdiagnosed at an earlier age. Lack of awareness amongst health care professionals and scarce treatment options in earlier days play an important role for these patients as well. We added a paragraph on symptomatic pectus excavatum in seniors to the introduction section, including the following references:

- Kragten HA, Siebenga J, Höppener PF, Verburg R, Visker N. Symptomatic pectus excavatum in seniors (SPES): a cardiovascular problem? : A Prospective cardiological study of 42 senior patients with a symptomatic pectus excavatum. *Neth Heart J*. 2011 Feb;19(2):73-8.
- Handels NA, Kragten HA, de Loos ER, Höppener PF. Long-term results of surgical correction of symptomatic pectus excavatum in seniors: Improvement in

cardiovascular function and quality of life. Ital J Vasc Endovasc Surg
2017;24(4):131-6.

- Winkens RA, Guldemon FI, Höppener PF, Kragten HA, Knottnerus JA.
Symptomatic pectus excavatum in seniors: an exploratory study on clinical
presentation and incidence in daily practice. ISRN Family Med. 2013 Feb
25;2013:373059.

Changes in text: page 4, lines 63-68; references 4, 5, 6 were added.

Comment 2: Could the authors explain what the banana chest shape means?

Reply 2: Thank you for your comment. A banana shaped deformity is an extreme bending deformity of the sternum, on sagittal CT-imaging mimicking the shape of a banana. Due to this morphological deformity, minimal invasive repair of pectus excavatum is seen as contraindicated and therefore open repair is often warranted. For clarity, we explained this term in our manuscript.

Changes in text: page 8, line 141

Comment 3: I suggest to include the description of statistical test used under each table.

Reply 3: We followed your suggestion and added descriptions under tables 1 and 2.

Changes in text: tables 1, 2.

Reviewer B

Comment 1: Well written paper with an important message. I only wonder why patients at 19 or 20 of age should be treated with a modified Ravitch because it is well known that patients up to 30-35 years might be corrected by a Nuss procedure without problems and then one keeps the natural cartilage in the patient.

Reply 1: Thank you for your comment. Indeed, minimal invasive repair of pectus excavatum by a Nuss procedure is seen as gold standard. The vast majority of young patients can perfectly be treated with Nuss bar placement. However, even in young patients, Nuss procedure is sometimes unfeasible, for example after prior pleurodesis or thoracic surgery, due to extreme sternal deformities of upon specific patient request. We clarified this in our manuscript.

Changes in text: page 7-8, lines 138-144.

Reviewer C

Comment 1: Introduction and discussion part are too long. Please reduce these parts.

Reply 1: Thank you for your comment. We reduced the non-essential parts.

Changes in text: page 4, lines 48-52; page 5, lines 73-75 and lines 79-80; page 6, lines 101-102 and lines 104-109.

Comment 2: After the Ravitch procedure a bar removable after consolidation is usually positioned. However, I guess that your technique outlines a permanent plate. This is not recommendable. Please better explain the technique.

Reply 2: Thank you for your comment. To achieve more stability, many techniques for extra retrosternal support are used by different pectus surgeons, varying from mesh support to hardware placement as for example Nuss or Rehbein bars. One disadvantage of these techniques could be the need for reoperation for hardware removal. The use of permanent plates could reduce this reintervention rate, under the condition that sufficient stability is provided. We clarified this in our revised manuscript.

Changes in text: page 11, lines 229-237.

Reviewer D

Comment 1: Why do you have a so big range of age in this kind of patients?

Reply 1: Most of the referred patients with a symptomatic pectus excavatum are adolescent and are treated with minimally invasive repair. In our case series, only patients unsuitable for Nuss bar placement are included. The big range of age is explained by the different indications for modified Ravitch procedure, varying from younger patients unsuitable for Nuss procedure due to for example pleurodesis or extreme sternal deformity, to elderly patients presenting with cardiovascular complaints at a later age. Symptomatic pectus excavatum in senior patients is an underestimated problem. Most of these patients are referred with cardiovascular complaints at an older age, while the severity of their pectus was misdiagnosed at an earlier age. Lack of awareness amongst health care professionals and scarce treatment options in earlier days play an important role in underdiagnosis in these patients as well. We added a paragraph on symptomatic pectus excavatum in seniors to the introduction section. Also, we clarified indications and contra-indications for minimal invasive and open pectus repair in the revised manuscript.

Changes in text: page 4, lines 63-68; page 7, lines 138-144.

Comment 2: It seems that you operated also patients quite old, as you indicated in table 1...this type of operation is usually more aesthetic than indicated for complications. I have some doubts that patients after 40 years old developed complications for pectus or aesthetical problems, if they not developed before, or asked for correction after 45 years old.

Reply 2: Thank you for your comment. Indications for pectus repair can be for aesthetic or physical complaints. We agree that older patients normally do not suffer from esthetical burdens, which is far more common in young persons. Senior patients with symptomatic pectus excavatum are mostly referred with cardiovascular complaints, while the severity of their pectus was misdiagnosed at an earlier age. Lack of awareness amongst health care professionals and scarce treatment options in earlier days play an important role in these 'late' referrals. We added a paragraph on symptomatic pectus excavatum in seniors to the introduction section, including the following references:

- Kragten HA, Siebenga J, Höppener PF, Verburg R, Visker N. Symptomatic pectus excavatum in seniors (SPES): a cardiovascular problem? : A Prospective cardiological study of 42 senior patients with a symptomatic pectus excavatum. *Neth Heart J.* 2011 Feb;19(2):73-8.
- Handels NA, Kragten HA, de Loos ER, Höppener PF. Long-term results of surgical correction of symptomatic pectus excavatum in seniors: Improvement in cardiovascular function and quality of life. *Ital J Vasc Endovasc Surg* 2017;24(4):131-6.
- Winkens RA, Guldemon FI, Höppener PF, Kragten HA, Knottnerus JA. Symptomatic pectus excavatum in seniors: an exploratory study on clinical presentation and incidence in daily practice. *ISRN Family Med.* 2013 Feb 25;2013:373059.

Changes in text: page 4, lines 63-68; references 4, 5, 6 were added.

Comment 3: In general, pectus excavatum correction is indicated in the range between 20 and 35 years old...you showed that for mesh all the patients undergone surgery for cardiac compression (100%), that is a very impressive data, in my experience I have never undergone surgery for pectus for cardiac symptomatic compression, especially after 40 years old.

Reply 3: Thank you for your comment. Unfortunately, symptomatic pectus excavatum in seniors is an often underestimated and misdiagnosed entity. In contrast to younger patients with pectus excavatum, older patients usually do not experience aesthetical problems. Upon

specific anamnesis, older patients often report to suffer from dyspnoe d'effort or dysrhythmias. When performing CT or MRI-scan in these selected symptomatic patients, cardiac impression can often be found. We added a paragraph on symptomatic pectus excavatum in seniors to the introduction section.

Changes in text: page 4, lines 63-68.

Comment 4: You showed the same problem as described in point 3 even for the locking compression plate technique. Could you please justify better point 3 and 4?

Reply 4: Indications for modified Ravitch procedure, either with cerclage wires and retrosternal mesh support or locking plate osteosynthesis are the same. Baseline characteristics of both groups are similar. Therefore, in both groups cardiac compression is just as often present.

Changes in text: none.

Comment 5: What do you mean for "other complications" in table 2?

Reply 5: We agree "other complications" is a confusing formulation. Complications other than hardware removal or non-union is meant. We clarified this in Table 2.

Changes in text: table 2.

Comment 6: In table 2, you declared six patients (23%) had hardware complications in locking compression plate, which were in total 26, is quite high. What does it happen exactly to this hardware in these cases? Could you please explain better?

Reply 6: Due to the rather bulky character of the used plates, some patients experience inconvenience from the plates. The six patients in our series were all bothered by the prominence of the plates and therefore requested for hardware removal. No hardware had to be removed due to infection or pain. We clarified this in the discussion section.

Changes in text: page 11, lines 212-214.

Comment 7: Has patient in figure 1 had severe problems for cardiac compression? Could you please show the figure before and after surgery in combination in one figure please?

Reply 7: The patient in figure 1 indeed complained of problems due to cardiac compression. In line with your suggestion, we combined the preoperative and postoperative photographs of the patient in Figure 1.

Changes in text: figure 1.

Comment 8: Could you also show the picture of a case of CT as example of patients who had a severe problem of cardiac compression?

Reply 8: According to your suggestion, we added a figure showing a CT-image with cardiac impression.

Changes in text: figure 3 was added.

Comment 9: Could you please notify the exact cardiac examinations before surgery who notified the severe cardiac problems, which justified these operations?

Reply 9: Thank you for your comment. Cardiac workup includes electrocardiography, echocardiography and dynamic cardiac MRI. When palpitations are part of the symptomatology, holter recordings are done (REF: Amulya K. Saxena: Chest Wall Deformities 2017, ISBN 978-3-662-53086-3 (Springer); chapter 21 Paul F. Höppener, Hans A. Kragten, Ron Winkens: cardiological aspects of Symptomatic Pectus Excavatum in Adults). Indications for surgical intervention based on cardiac problems are: i. impression of the pectus on the right ventricle of the heart established by echocardiography or MRI, ii. exercise intolerance, iii. arrhythmias.

We added the cardiac work-up to the Patients and Methods section.

Changes in text: page 7, lines 129-135, reference 12 was added.

Comment 10: Figure 3 is not clear at all. Could you please show a better picture or a combination of surgical technique figures for both the different types of operation?

Reply 10: Thank you for your comment. Unfortunately no other surgical technique photographs are currently available. Since fixation of the sternal osteotomy with cerclage wires and retrosternal mesh support was last performed in our hospital in 2012, it is not possible for us to generate new photographs. To clarify Figure 3, we added text with anatomical landmarks.

Changes in text: figure 4 (formerly figure 3).

Comment 11: In figure 5 could you please add the section of transverse CT scan where is visible the pectus depression and cardiac compression?

Reply 11: Thank you for your comment. We adjusted the figure and added a transverse section of a postoperative CT-scan.

Changes in text: figure 6 (formerly figure 5)

Comment 12: Figure 4 needs to be implemented with more figures regarding the steps of the technique. You can also add all inside the same figure.

Reply 12: Thank you for your comment. Unfortunately, no more peroperative photographs are available. To clarify Figure 4, we added text with anatomical landmarks and changed the orientation of the photograph to a more natural point of view.

Changes in text: figure 5 (formerly figure 4).

Comment 13: You did not describe anything about pre-operative findings regarding the patients which should have driven your decision to opt for surgical correction. Could you better write this methods section, please? Do the patients perform pulmonary functional test and echocardiogram?

Reply 13: Thank you for your comment. Cardiac workup includes electrocardiography, echocardiography and dynamic cardiac MRI. When palpitations are part of the symptomatology, holter recordings are done. If necessary, pulmonary function tests including trifold forced inspiration tests are conducted. Indications for surgical intervention are: a. impression of the pectus on the right ventricle of the heart established by echocardiography or MRI, b. exercise intolerance, c. arrhythmias, d. psychosocial problems due to aesthetic complaints.

We added further information on cardiopulmonary workup and indications for surgical intervention to the Methods section.

Changes in text: page 7, lines 129-135.

Comment 14: You define this study as retrospective cohort study. How did you select and choose the patients for one or for the other technique?

Reply 14: Thank you for your comment. Selection of different surgical techniques was based on historical grounds. Until 2012, fixation of the sternal osteotomy with cerclage wires and retrosternal mesh support was standard of care in our practice. From 2012, we changed our treatment protocol to locking plate osteosynthesis as standard treatment. We clarified this in the revised version of our manuscript.

Changes in text: page 8, lines 151-152.

Comment 15: Have you received an Ethical Board Committee approval for this Study? Have the patients signed a consent form to be enrolled? Into the methods I cannot see this section.

Reply 15: Thank you for your comment. This retrospective study was approved by the local ethics and clinical research committee, waiving the need for individual patient consent (METC Zuyderland, ID: METCZ20200049). We added this information to the Methods section.

Changes in text: page 8, lines 156-159.