Journal of Pediatric Surgery 52 (2017) 1545–1552

Contents lists available at ScienceDirect

Journal of Pediatric Surgery

journal homepage: www.elsevier.com/locate/jpedsurg

Meta-Analyses/Review Articles

Comparison of the Nuss versus Ravitch procedure for pectus excavatum repair: an updated meta-analysis

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ARTICLE INFO

Article history:
Received 6 March 2017
Received in revised form 16 May 2017
Accepted 29 May 2017

Key words:
Pectus excavatum
Funnel chest
Nuss
Ravitch
Minimally invasive
Open surgery

ABSTRACT

Background/purpose: To evaluate surgical outcomes of Nuss versus Ravitch repair of pectus excavatum via a systematic review and meta-analysis.

Methods: Medline, PubMed, Cochrane, EMBASE, and Google Scholar databases were searched up to September 5, 2016 using the following search terms: pectus excavatum, funnel chest, Nuss; Ravitch, minimally invasive, and open surgery. Randomized controlled trials, two-arm prospective, and two-arm retrospective studies were eligible for inclusion.

Results: Nineteen studies were included with a total of 1731 patients: 989 treated with Nuss and 742 treated with Ravitch. The overall analysis revealed that patients in the Nuss group had significantly shorter operation time (pooled SMD = −2.83, 95% CI = −3.76 to −1.90, $p < 0.001$) and less blood loss (pooled SMD = −1.68, 95% CI = −2.28 to −1.09, $P < 0.001$) than the Ravitch group. However, the length of hospital stay was similar between groups (pooled SMD = −0.55, 95% CI = −1.44 to 0.35, $p = 0.230$). These findings were similar in the subgroup analysis for randomized and non-randomized controlled studies. Complications were not assessed due to inconsistent reporting across the included studies.

Conclusions: Our meta-analysis demonstrate that the Nuss procedure has a shorter operative time and less operative blood loss than the Ravitch procedure while the postoperative length of stay was similar.

Levels of evidence: Level III.

Pectus excavatum is the most common congenital chest deformity, characterized by a depression in the anterior chest wall due to dorsal deviation of the sternum and the third to seventh rib or costal cartilage [1,2]. Pectus excavatum affects about one to eight per 1000 live births [1]. The depression of the sternum can displace the heart and reduce the lung volume, and may cause physiological problems such as pulmonary and cardiovascular impairments [2–4]. Pectus excavatum can result in chest pain, fatigue, dyspnea, and exercise intolerance [5]. In addition intensity/degree of the symptoms can be impacted by the severity of the deformity. For example, morphological differences in pectus excavatum may result in different effects on pulmonary function, as well as cardiac morphology and function [5,6]. It is also associated with cosmetic problems and psychological symptoms, including issues regarding body image which may significantly impact a person's quality of life [5,7]. Symptoms of untreated patients can progress with age, and it is recommended that the deformity is surgically treated in both young and adult patients [2]. In support of this, a number of clinical studies have shown improvement of pulmonary and/or cardiovascular symptoms and patient quality of life following surgical repair [8–11].

Several techniques have been used to correct this deformity, the most common being that developed by Ravitch in 1949 [12]. This procedure is an open technique which involves complete resection of the cartilage, xiphoid excision, and osteotomy of the sternum when first introduced [12]. Since its initial introduction, modifications of this procedure have been developed including placement of a metal strut, to support the sternum, that is removed after six months to a year [13–17]. In 1998, a new method was introduced by Nuss et al., which is a minimally invasive [18]. Unlike the Ravitch procedure, which uses a single incision in the center of the chest, the Nuss is a minimal technique that uses a small incision on the lateral side of the chest wall under the arms [12,18]. The Nuss procedure, raises the sternum using a retrosternal metallic bar and is based on the fact that the thorax of young subjects is flexible making an effective correction possible without costal cartilage resection or sternal osteotomy [2,19]. Nuss et al. suggested that the technique resulted in reduced blood loss and shorter operative times [18].

Both procedures are currently used. Several comparative studies have been published evaluating both procedures with inconsistent

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http://dx.doi.org/10.1016/j.jpedsurg.2017.05.028
0022-3468/

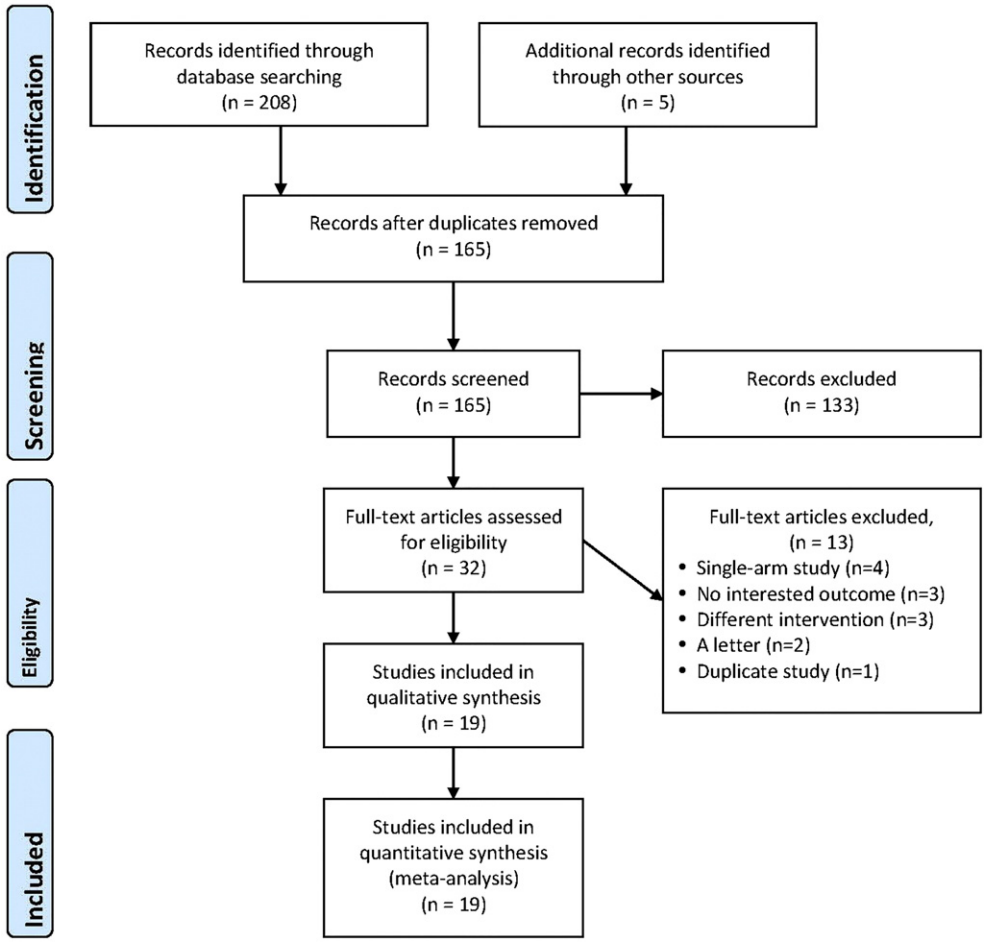

Fig. 1. Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow diagram.

results. The aim of this study was to evaluate surgical outcomes of Nuss versus Ravitch repair of pectus excavatum

1. Methods

The study was performed following the PRISMA guidelines. Medline, PubMed, Cochrane, EMBASE, and Google Scholar databases were searched up to September 5, 2016 using the following search terms: pectus excavatum, funnel chest, Nuss, Ravitch, minimally invasive, and open surgery. Randomized controlled trials (RCTs), two-arm prospective, and two-arm retrospective studies were included. Included studies had to have compared outcomes of Nuss repair or Ravitch repair in patients (either children or adults) with pectus excavatum (funnel chest). All studies had to present outcomes of interest quantitatively. One-arm studies, letters, comments editorials, case reports, proceedings, and personal communications were excluded. The reference list of included papers was hand-searched to identify other eligible studies.

1.1. Study selection and data extraction

Studies were reviewed for inclusion by two independent reviewers. In cases of uncertainty regarding eligibility, a third reviewer was consulted. The following information/data was extracted from studies that met the inclusion criteria: the name of the first author, year of publication, study design, number of participants in each group, patients' age and gender, and the major outcomes.

1.2. Quality assessment

The quality of the included studies was evaluated using ACROBAT-NRSI [20].

1.3. Contents outcome measures

The primary outcome was difference in operative time between two groups. Secondary outcomes included difference in blood loss and length of hospital stay between two groups.

1.4. Statistical analysis

The standard mean difference (SMD) with 95% confidence intervals (CIs) between patients with pectus excavatum repaired by Nuss and Ravitch methods was calculated for continuous outcome. If data on mean and SMD were not available, then the median, range, and the size of a sample were used to estimate the mean and variance [21]. If the median and interquartile range (IQR) was reported in a study, we assumed that the median of the outcome variable was equal to the mean response and width of the interquartile range was approximately 1.35 the standard deviation [22]. Data heterogeneity was determined using a χ2-based test of homogeneity and the inconsistency index (I^2) and Q statistics. If the I^2 statistic were >50%, indicating the presence of heterogeneity, a random-effects model was used. Otherwise, fixed-effect model was employed. Pooled effects were calculated and a 2-sided P value <0.05 was considered to indicate statistical significance. Prospective subgroup analysis was performed per study design (randomized and non-randomized studies). Sensitivity analysis was