Applicability of Clavien-Dindo classification in Nuss procedure surgical complications

C. Esteva Miró, B. Núñez García, M. Pérez-Gaspar, S. Santiago Martínez, J. Jiménez Gómez, J.E. Betancourth Alvarenga, P. Jiménez-Arribas, N. Álvarez García

Pediatric Surgery Department. Consorci Corporació Sanitària Parc Taulí. Sabadell (Barcelona) (Spain).

ABSTRACT

Objectives. Nuss procedure is a safe surgery but not exempt from complications. Clavien-Dindo classification (1992) allows complications of any surgery to be recorded. Our objective was to prove its applicability in the study of Nuss procedure complications.

Materials and methods. We present a retrospective series of PE patients undergoing surgery from January 2010 to January 2018. Nuss procedure associated morbidity prior to bar removal was studied. Complications were stratified according to Clavien-Dindo classification.

Results. A total of 31 patients were included. Mean age was 14.67 years (4-27 years), with a mean Haller index of 6.06 (3.35-14.14) and a mean correction index of 41.2% (16-87%). Clavien-Dindo classification I-IIIb mild complications were recorded in 35.48% of patients. Seroma was found in 4 patients (12%), of whom 1 had superinfection and 1 had wound dehiscence. In 6 patients, bar and/or stabilizer mobilization was noted, and in 1 patient, postoperative acute pulmonary edema (3%) was observed. Of the 11 patients with complications, only 6 required re-intervention –5 as a result of prosthesis mobilization, and 1 as a result of infection not resolved with intravenous antibiotic therapy.

Conclusions. Clavien-Dindo classification is being increasingly used as a way of unifying surgical complication criteria by comparing results. Our study demonstrated that such classification is a feasible and reproducible method when it comes to reflecting Nuss procedure morbidity and comparing it with other groups.

KEY WORDS: Pectus Excavatum, Nuss, Complications, Clavien-Dindo.

Corresponding author: Dr. Clara Esteva Miró.
E-mail address: cesteva@tauli.cat

This work was presented as an oral communication at the Spanish Society of Pediatric Surgery Congress held in Granada in 2018.

Date of submission: April 2020 *Date of acceptance:* May 2020

APLICABILIDAD DE LA CLASIFICACIÓN CLAVIEN-DINDO EN LAS COMPLICACIONES QUIRÚRGICAS DEL PROCEDIMIENTO DE NUSS

RESUMEN

Objetivos. La intervención de Nuss es una cirugía segura pero no está exenta de complicaciones. La clasificación de Clavien-Dindo (1992) permite registrar complicaciones de cualquier operación. Nuestro objetivo es demostrar la aplicabilidad de dicha clasificación para el estudio de las complicaciones de la cirugía de Nuss.

Material y métodos. Presentamos una serie retrospectiva de pacientes afectos de PE intervenidos entre enero 2010 y enero 2018 y su morbilidad asociada a la cirugía de Nuss hasta la retirada de la barra. Dichas complicaciones se agruparán mediante la clasificación de Clavien-Dindo.

Resultados. Se recogen un total de 31 pacientes. La media de edad fue 14,67 años (4-27 años), con una media de índices de Haller de 6,06 (3,35-14,14) y una media de índices de corrección de 41,2% (16-87%). Se observaron complicaciones leves I-IIIb de la clasificación de Clavien-Dindo en el 35,48% de los pacientes. Se constató seroma en 4 pacientes (12%), de los cuales 1 presentó sobreinfección y otro, dehiscencia de herida. En 6 pacientes se observó movilización de la barra y/o estabilizador y en 1 paciente, edema agudo de pulmón postoperatorio (3%). De los 11 pacientes que presentaron complicaciones, solo 6 requirieron reintervención: 5 de ellos por movilización de la prótesis y uno por infección no resuelta con antibioterapia endovenosa.

Conclusiones. La clasificación de Clavien-Dindo se emplea cada vez más como una forma de unificar los criterios de las complicaciones quirúrgicas permitiendo comparar los resultados obtenidos. Comprobamos que es perfectamente factible y reproducible para reflejar la morbilidad del procedimiento quirúrgico de Nuss y poder compararla con otros grupos.

PALABRAS CLAVE: Pectus excavatum; Nuss, Complicaciones, Clavien-Dindo.

INTRODUCTION

Thoracic cage congenital malformations occur in 1 out of 1,000 children, with pectus excavatum (PE) representing up to 88% of cases. This deformity involves a central

Table 1. Clavien–Dindo classification of surgical complications.

I	Any deviation from the normal postoperative course without the need for pharmacological treatment or surgical, endoscopic, and radiological interventions Allowed therapeutic regimens are: drugs as antiemetics, antipyretics, analgetics, diuretics, electrolytes, and physiotherapy. This grade also includes wound infections opened at the bedside
II	Complications requiring pharmacological treatment with drugs other than such allowed for grade I complications Blood transfusions and total parenteral nutrition are also included
III	Complications requiring surgical, endoscopic, or radiological intervention
IIIa	Intervention not under general anesthesia
IIIb	Intervention under general anesthesia
IV	Life-threatening complications (including CNS complications) requiring ICU management
IVa	Single organ dysfunction (including dialysis)
IVb	Multiorgan dysfunction
V	Death of the patient

Suffix "d"
Complications that have the potential for long-lasting disability after patient's discharge are highlighted by a suffix ("d" for disability) to the respective grade of complication
This suffix indicates that a follow-up is required to comprehensively evaluate the outcome and related long-term quality of life

depression of the thoracic cage which can be symmetric or asymmetric[1].

PE not only causes esthetic issues, but also various cardiovascular and/or respiratory symptoms, according to severity. The most frequent symptoms include decreased cardiac output, mitral valve prolapse, cardiac arrhythmia, restrictive pulmonary disease, pulmonary atelectasis, and paradoxical breathing[1-5].

Various therapeutic options have been proposed. However, since it was first described in 1998, Nuss procedure has become the most widely used surgery for PE correction[2-5].

It is a minimally invasive procedure as compared to older techniques, but it is not exempt from complications both in the immediate and long-term postoperative period[5-8].

In 1992, Clavien published a classification of surgical complications based on the treatment required for correction[9]. However, in 2004, and along with Dindo, they both redefined the categories into 5 grades[10], as demonstrated in Table 1.

In 2009, Clavien[11] published the first multicenter study, which analyzed and assessed the classification's effectiveness in terms of recording and comparing the surgical complications of various surgical techniques and healthcare facilities.

This classification is being increasingly used in various specialties, including pediatric surgery[12,26]. However, application in the study of video-assisted Nuss thoracoplasty in pediatric patients has not been assessed yet.

The objective of this work was to demonstrate the usefulness of this classification and its applicability when it comes to categorizing and stratifying pectus excavatum surgical complications following Nuss technique.

MATERIALS AND METHODS

A descriptive, retrospective study of complications associated with video-assisted Nuss thoracoplasty for PE repair was carried out.

PE patients undergoing surgery and bar removal after treatment completion in our healthcare facility from January 2010 to January 2018 were included. PE patients not undergoing surgery as a result of not meeting surgical indication criteria and PE patients already operated on, including those having undergone a different procedure from Nuss thoracoplasty, were excluded.

In all patients, a preformed Nuss bar was placed through unilateral thoracoscopy and bilaterally fixed using metallic stabilizers.

All complications in the first 3 months following bar removal were recorded, with complications being defined as any deviation from the normal postoperative course. Postoperative complications were identified, quantified, and stratified according to Clavien-Dindo classification criteria.

Clavien-Dindo classification (Table 1) is a stratification of postoperative complications based on objective data. It defines the various categories according to the medical resources required for treatment[9,10]. Categories I-II are considered mild, whereas categories III-V are considered severe.

Given that it is based on objective data, it can be reproduced in any procedure and used to compare techniques and healthcare facilities[11].

The current classification, which is based on that of 2004, does not consider hospital stay as an indicator of severity. The suffix "d" was added to the 1992 classification, which allowed patient perspective to be taken into account for complication severity estimation.

Therefore, it is a physician and patient perspective based resource that stresses treatment risk and invasiveness, which allows subjective connotations in postoperative event interpretation to be minimized.

There is a growing number of references in the literature on the use of Clavien-Dindo classification in pediatric surgery[12-26]. They all describe it as a useful tool for complication severity categorization purposes.

Table 2. Series characteristics.

Mean age	14.67 (4-27)
Sex	
– Male	67.74% (21)
– Female	32.25% (10)
Symptoms	93.54% (29)
– Asthenia	77.41% (24)
– Thoracic pain	45.16% (14)
– Respiratory infections	19.35% (6)
Psychological involvement	80.64% (25)
Complementary tests	100% (31)
– Thoracic CT-scan	100% (31)
- Mean Haller index	6.06 (3.35-14.14)
- Mean correction index	41.2% (16-87%)
– Echocardiography	61.29% (19)
- Abnormal	15.78% (3)
– Ergospirometry	38.70% (12)
- Abnormal	91.66% (11)

Table 3. Surgery and postoperative course characteristics.

Surgery data		
Nuss bar	31	100%
Stabilizers	31	100%
Thoracoscopy	31	100%
Previous sternal elevation	5	23.80%
Subcutaneous drainage	0	0%
Thoracic drainage	2	6.45%
Postoperative data		
Mean UCI stay (days)	3.06 (1-5)	
Mean hospital stay (days)	7.90 (5-16)	
Media de días con catéter peridural	3.06 (1-6)	
Mean duration of epidural catheterization (days)	5 (3-14)	
Mean duration of oral analgesia (days)	27.16 (14-60)	

RESULTS

In the 8 study years, a total of 59 PE patients were operated on, 31 of whom underwent surgical correction according to Nuss technique.

Demographic and clinical characteristics are featured in table 2.

Mean age at surgery was 14.67 years, with 67.74% of male patients.

The most frequent preoperative symptoms included asthenia (77.41%), thoracic pain (45.16%), and respiratory infections (19.35%). Up to 25 of the 31 study patients (80.64%) had psycho-emotional disorders, such as low self-esteem as a result of physical appearance, fear to other people's refusal, and social avoidance behavior.

Regarding complementary tests, a thoracic CT-scan was performed in 100% of patients. This allowed Haller index, with a mean value of 6.06 (3.35-14.14), and correction index, with a mean value of 41.2% (16-87%), to be calculated. Further anatomic disorders were searched for, but they were not found.

Echocardiography was carried out in 61.29% of patients, without significant findings, except for 3 patients (9.67%) where unimportant disorders with no clinical significance, such as mild tricuspid insufficiency or ventricular extrasystole, were found. Echocardiography indication was performed based on symptoms, as explained by patients themselves.

Ergospirometry was conducted in 38.7% of patients, with abnormal results in 91.66% of cases. Most patients had normal values at rest, but abnormal values during exercise, with significantly decreased forced expiratory volume (FEV1) and forced vital capacity (FVC).

Surgery and postoperative course characteristics are demonstrated in table 3.

A Nuss bar with a stabilizer in each hemithorax was placed in all patients, under thoracoscopic vision. In 5 patients (16.12%) with severe malformation (>9 Haller index), sternal elevation was carried out to facilitate bar passage through the retrosternal space.

None of the patients required subcutaneous drainage, and only two patients (6.45%) required thoracic drainage in the immediate postoperative period as a result of residual pneumothorax.

Patients had a mean Pediatric Intensive Care Unit (P-ICU) stay of 3.06 days (1-5). The main reason for long P-ICU stay was poor postoperative pain control. Mean hospital stay was 7.90 days (5-16), with mean duration of epidural catheterization being 3.06 days (1-6), and mean duration of intravenous analgesia being 5 days (3-14). Mean duration of oral analgesia was 27.16 days (14-60).

Complications were noted in 11 patients (35.48%). A total of 15 complications were recorded, since some of them were secondary to others (Table 4).

In 4 patients (12.90%), seroma occurred. 2 resolved spontaneously, 1 had wound superinfection, and the remaining 1 had suture dehiscence and bar mobilization.

In total, 6 patients (19.35%) had bar and/or stabilizer mobilization. 2 (6.45%) had bar mobilization with intra-

Table 4. Complications by patient.

Patient	*Complications*	*Treatment*	*Clavien-Dindo grad*
1	Stabilizer mobilization + suture dehiscence	Surgery	IIIb
2	Seroma	Spontaneously resolved	I
3	Seroma + stabilizer mobilization + suture dehiscence	Surgery	IIIb
4	Bar mobilization	Surgery	IIIb
5	Acute pulmonary edema	Drug treatment and respiratory physiotherapy in the pediatric unit	II
6	Stabilizer mobilization	No treatment required. Bar removal surgical finding	I
7	Seroma	Spontaneously resolved	I
8	Bar mobilization	Surgery	IIIb
9	Seroma + wound superinfection	Antibiotic therapy	II
10	Wound infection	Surgery	IIIb
11	Stabilizer mobilization	Surgery	IIIb

thoracic migration, and the remaining 4 had detachment of one of the stabilizers (of the bar).

1 patient had acute pulmonary edema, but it did not require ICU admission and was resolved with drug therapy and respiratory physiotherapy.

Of the aforementioned patients, 6 (19.35%) required re-intervention. None of them required a third surgery. 2 patients had bar intrathoracic migration, one of them 2 months following thoracoplasty, and the other one 1.5 years following surgery. In both cases, thoracoscopy was used to re-place the bar and fix it to the stabilizers; postoperative course was uneventful. In the remaining 3 patients, re-intervention demonstrated bar detachment from one of the stabilizers, as well as wound dehiscence in 1 patient. These complications were found 17 months, 2 months, and 14 months following thoracoplasty. In these 3 patients, only one intervention was needed to re-place the bar inside the stabilizers and fix it to them, which means no intra-thoracic approach was required. Finally, 1 patient required surgical review and cleansing as a result of wound infection 10 days following Nuss bar removal surgery. The infection was limited to the subcutaneous plane, so no intra-thoracic approach was needed.

All patients requiring re-intervention as a result of bar and/or stabilizer mobilization underwent surgery in the first 2 years of the series. At that time, an absorbable braided suture was used to fix the bar to the stabilizers, but it was subsequently reinforced with an absorbable monofilament suture while adding more fixation points.

No cardiac, pericardial, mediastinal, or pulmonary perforations were observed, and no rib fracture, death, or other important complications among those described in the literature were noted[8]. No thoracic defect overcorrection was evidenced either.

Table 5. Categorization of complications according to Clavien-Dindo classification.

I	3	9.67%
II	2	6.45%
IIIa	0	–
IIIb	6	19.35%
IVa	0	–
IVb	0	–
V	0	–

Table V features the number of complications found in the study according to Clavien-Dindo classification grades. The classification establishes that, if various complications are noted in one single patient, the most severe one will be considered for stratification purposes.

In these series, 11 patients (35.48%) had complications, 6 (19.35%) of which severe, since they required re-intervention under general anesthesia.

DISCUSSION

Pectus excavatum (PE) is a congenital malformation of the thoracic cage with potential functional and psychoemotional consequences for patients[1].

Over the years, it has been treated using various surgical techniques, which have been increasingly less invasive. First described in 1998[3], minimally invasive thoracoplasty according to Nuss technique has been widely used in several countries. It has proved to reduce clinical signs caused by ongoing lung and mediastinal structure compression[1-5].

Like other surgeries, it is not exempt from complications. It is a minimally invasive procedure as compared to older techniques, but it is carried out in an anatomical space where many noble structures are close to one another. The most frequent early complications include pneumothorax, hemothorax, pleural effusion, pericarditis, wound infection, and pneumonia. The most frequent late complications are bar mobilization, metal allergies, and overcorrection. Other less frequent but much more severe complications include pericardial or cardiac perforation, pulmonary perforation, mediastinitis, Horner syndrome, and death[1-8].

Until 1992, complications used to be classified according to severity, which was subject to medical personnel interpretation. However, Clavien-Dindo classification allows for a fully objective stratification by considering both physicians' and patients' perspective. Therefore, not only does this classification offer easy interpretation, but it also helps categorize new events which do not follow the normal postoperative course.

In other publications, this classification has been used to compare complications associated with the same procedure in different healthcare facilities. Consequently, it has been proposed as a useful tool to assess the results of certain surgeries in different hospitals and come to conclusions.

In 2013, Fallon et al., presented a series of 127 patients undergoing Nuss thoracoplasty from 2003 to 2011. Most patients were male (86%), and mean age at surgery was 14.8 years. According to their calculations, they found complications in up to 33 patients (26%), 25% of whom required re-intervention. However, given that the paper does not feature a clear description of the series, complications cannot be categorized according to Clavien-Dindo classification, which means it cannot be used for comparison purposes[27].

The objective of our study was to demonstrate Clavien-Dindo classification's usefulness by applying it in a series of PE patients undergoing video-assisted Nuss thoracoplasty in our healthcare facility. The main limitation of this study, apart from being a retrospective one, lies in the fact that patient sample was quite small, which means results could be less reliable than those reported in the literature.

However, we believe Clavien-Dindo classification represents a simple, objective, and reproducible tool for the study of postoperative complications[10-11], and especially of complications following Nuss minimally invasive thoracoplasty for PE treatment.

In our view, this useful tool should be applied in other pediatric surgery procedures for surgical complication standardization, classification, and group comparison purposes.

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