

# Clavien-Dindo classification: a tool to assess complications following surgical treatment in children with acute appendicitis

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## ABSTRACT

**Introduction.** In pediatrics, there are few standard criteria to classify and consolidate postoperative complications, particularly in appendectomy, where according to the literature, complications range from 5% to 30%.

**Methods.** A cross-sectional, observational, retrospective study of patients undergoing surgery as a result of suspected acute appendicitis (AA) from December 2018 to January 2020 was carried out. Complications were grouped and consolidated according to the Clavien-Dindo (CD) classification. Postoperative complications and factors involved were analyzed by conducting a bivariate and multivariate statistical study using SPSS statistical software, version 25.

**Results.** A total of 124 patients were studied. Mean age was 9 years (3-14 years). 62% were boys, and 38% were girls. All patients underwent appendectomy – 80.6% through laparotomy, and 19.4% through laparoscopy. 20% of patients had postoperative complications, which were grouped according to the CD classification ( $p = 0.002$ ). Most complications were included in the CD I group (64%). Collections treated with antibiotic therapy were included in the CD II group (28%). Intra-abdominal collections requiring re-intervention for drainage purposes were included in the CD IIIb group (8%). The main factors driving complications were complicated AA (81% gangrenous and perforated) ( $p < 0.001$ ) and progression time (80%  $>24$  h of progression) ( $p = 0.036$ ), which increased mean hospital stay by  $7 \pm 4$  days ( $p = 0.016$ ).  $137 \pm 37$  CRP levels were associated with plastron identification ( $p < 0.001$ ), whereas  $109 \pm 19$  CRP levels were associated with peritonitis ( $p < 0.001$ ).

**Conclusions.** The Clavien-Dindo classification allows post-appendectomy complications in pediatric surgery to be classified using a common language, by associating complication grade with treatment complexity.

**KEY WORDS:** Clavien-Dindo; Appendectomy; Complications.

## CLASIFICACIÓN DE CLAVIEN-DINDO. HERRAMIENTA PARA EVALUAR LAS COMPLICACIONES TRAS EL TRATAMIENTO QUIRÚRGICO EN NIÑOS CON APENDICITIS AGUDA

### RESUMEN

**Introducción.** En pediatría hay pocos criterios estándares para clasificar y unificar las complicaciones postquirúrgicas y en particular en la apendicectomía, donde, según la literatura, las complicaciones varían de un 5-30%.

**Métodos.** Realizamos un estudio retrospectivo, observacional tipo transversal de los pacientes intervenidos por sospecha de apendicitis aguda (AA) durante diciembre 2018 a enero 2020. Las complicaciones fueron agrupadas y unificadas según la clasificación de Clavien-Dindo (CD). Se analizan las complicaciones postoperatorias y factores implicados, aplicando estudio estadístico bivalente y multivariante según el programa estadístico SPSS versión 25.

**Resultados.** Un total de 124 pacientes incluidos. Edad media 9 años (3-14 años). 62% niños, 38% niñas. A todos se les realizó apendicectomía, el 80,6% apendicectomía abierta, 19,4% por laparoscopia. El 20% presentó algún tipo de complicación en el postoperatorio y fueron agrupadas según la clasificación de CD ( $p = 0,002$ ). En CD I (64%) se incluyen la mayoría de las complicaciones, En el grupo CD II (28%) colecciones tratadas con antibioticoterapia. En el grupo CD IIIb (8%), colección intraabdominal que requirió reintervención para su drenaje. Los principales factores implicados en la aparición de complicaciones fueron: AA complicadas (81% gangrenosas y perforadas) ( $p < 0,001$ ), tiempo de evolución (80%  $>24$  h de evolución) ( $p = 0,036$ ) que incrementó la estancia media  $7 \pm 4$  días ( $p = 0,016$ ). El valor de proteína C reactiva (PCR) ( $137 \pm 37$ ) se relacionó con la identificación de plastrón ( $p < 0,001$ ), y el valor de PCR ( $109 \pm 19$ ) con peritonitis ( $p < 0,001$ ).

**Conclusiones.** La clasificación de Clavien-Dindo permite utilizar un lenguaje común para clasificar las complicaciones postapendicectomía en cirugía pediátrica, expresando el grado de estas según complejidad del tratamiento utilizado para su resolución.

**PALABRAS CLAVE:** Clavien-Dindo; Apendicectomía; Complicaciones.

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## INTRODUCTION

Acute appendicitis is a common cause of abdominal pain both in adults and children. It represents the most frequent surgical emergency globally<sup>(1-4)</sup>. The analysis of the volume-result ratios in adult surgery has found that surgeon and hospital features have an impact on patient results, such as hospital stay, hospital expenses, complications, and mortality. However, in pediatric surgery, less research has been made, and conclusions are less clear<sup>(5)</sup>. Various authors are still engaged in a fierce debate regarding the universal definition of “complications,” from the original definition by Clavien – “Complications are unexpected events non intrinsic to the procedure”<sup>(6)</sup> – to Sokol and Wilson’s variation – “Complications are any undesirable, unintended, and direct result of an operation affecting the patient, which would not have occurred had the operation gone as well as could reasonably be hoped”<sup>(7)</sup>. Postoperative complications represent a significant quality indicator – they delay recovery, make hospital stay longer, and increase morbidity and mortality rates<sup>(8)</sup>. In 1992, Clavien proposed a stratification of complication severity. This classification was subsequently improved by Dindo, giving rise to the Clavien-Dindo classification in 2004<sup>(6,9,10)</sup>.

This classification is based on the therapeutic consequences of complications, which allows for a simple, objective, and reproducible approach for the full assessment of surgical results<sup>(9,11)</sup>.

The usefulness of the Clavien-Dindo classification lies in assessing safety, comparing various approaches based on a standardized classification, analyzing learning curves of surgical techniques, performing internal quality controls, and standardizing surgical mistakes, thus improving management and prevention<sup>(12)</sup>.

In pediatrics, there are few standard criteria allowing postoperative complications to be classified and consolidated<sup>(5,9,10)</sup>, particularly in appendectomy<sup>(13)</sup>, where according to the literature, complications range from 5% to 30%<sup>(14)</sup>. Complication risk increases with disease severity<sup>(15)</sup>. Previous studies have identified potential risk factors which could cause postoperative complications, including age, time to surgery, presence of an appendicolith, microbiological factors, geographic location, race, social and economic level, and access to medical insurance<sup>(16,17)</sup>. Most studies demonstrate better surgical results in children treated by pediatric surgeons in pediatric hospitals<sup>(13)</sup>.

## METHODS

A cross-sectional, observational, retrospective study of patients undergoing acute appendicitis (AA) surgery following clinical or radiological diagnosis at a third-level pediatric hospital from December 2018 to January 2020 was carried out.

All patients (n = 124) were treated according to the fast-track therapeutic model for complicated acute appendicitis in pediatric patients, thus limiting variability in all care stages<sup>(18)</sup>.

Cases included were identified based on electronic clinical records from Andalusian Healthcare Department’s Diraya program (DSAS). Demographic, disease, and treatment data were retrieved from the DSAS, including age at admission, sex, origin, imaging tests such as ultrasonography or CT-scan, blood tests (leukocyte, neutrophil, and C-reactive protein count), time from symptom onset to surgery (progression time), open or laparoscopic approach, appearance of the cecal appendix at surgery, pathological diagnosis, hospital stay, and postoperative complications. Appendectomy in the context of another digestive pathology (colonic resection), as well as patients diagnosed with appendicular plastron using imaging techniques –management of appendicular plastron patients in our institution is initially conservative, followed by deferred surgery<sup>(19)</sup>–, were excluded. However, patients diagnosed with appendicular plastron at surgery were considered in this study. It should be highlighted that imaging tests are not carried out in all patients with abdominal pain at the right iliac fossa – high diagnostic suspicion of acute appendicitis is often sufficient to indicate surgery. Clinical judgment remains the most important factor in the treatment of patients with suspected acute appendicitis<sup>(20,28)</sup>.

Demographic data were featured as a descriptive statistic (Table I). The presence of complications was considered as the primary result in the multivariate analysis. Complications were grouped and consolidated according to the Clavien-Dindo (CD) classification (Table II)<sup>(21)</sup>. Complicated appendicitis was defined as the presence of widespread peritonitis or gangrenous/perforated appendix as assessed by the surgeon. Non-complicated appendicitis was defined as erythematous or phlegmonous appendix. Collection or intra-abdominal abscess was defined as the accumulation of postoperative intra-abdominal fluid as identified by ultrasonography or CT-scan (Table III). Postoperative complications and factors involved were analyzed by conducting a bivariate and multivariate statistical study using SPSS statistical software, version 25.

## RESULTS

In the study period, a total of 124 patients underwent surgery as a result of high diagnostic suspicion of acute appendicitis. Mean age was 9 years (3-14 years). 62% of patients were boys, and 38% were girls. All patients underwent appendectomy – 80.6% through laparotomy, and 19.4% through laparoscopy. Surgeries were carried out by deputy surgeons and pediatric surgery fellows from a third-level pediatric university hospital.

Of the 20% of patients who developed complications (Table III), 16 cases belonged to the CD I group, 7 cases

**Table I. Epidemiological data.**

	<i>All</i>	<i>Complications</i>	<i>Statistical analysis</i>
	<i>Patients (n = 124)</i> <i>Mean ± SD (min-max)</i>	<i>Patients (n = 25)</i> <i>Mean ± SD (min-max)</i>	<i>Chi square <math>\chi^2</math> (p value)</i> <i>(p = 0.002)</i>
<b>Age (years) &lt;5 years</b>	9 ± 2.85 (2-14) n = 16	8.8 ± 3.11 (5-13) n = 5	OR: 1.63 (1.33-2)*
<b>Sex (male/female)</b>	77:47 (62%/38%)	14:11 (56%/44%)	
<b>Analytcs</b>			
– Blood count leukocytes (x 10 <sup>3</sup> /µl)	15.9 ± 5	17.63 ± 5.36	
– Neutrophils (%)	79.6 ± 8.6	82.33 ± 7.93	
– CRP (mg/L)	50.3 ± 68.52	70.29 ± 71.31	
<b>Preoperative imaging test</b>	86 (70%)	19 (76%)	
<b>Origin (urban/rural)</b>	45/79 (36%/64%)	9/16 (36%/64%)	
<b>Hours of progression</b>			p < 0.036*
– <12 h	13 (10%)	0	
– 12-24 h	40 (32%)	5 (20%)	
– 24-48 h	37 (30%)	10 (40%)	
– 48-72 h	20 (17%)	6 (24%)	
– 72-96 h	14 (11%)	4 (16%)	
<b>Approach (LT/LP)</b>	(100/24) (80.6%/19.4%)	(20/5) (80%/20%)	
<b>Surgical findings</b>			p < 0.001*
– No inflammation	10 (8%)	1 (4%)	
– Phlegmonous	60 (48%)	2 (8%)	
– Gangrenous	26 (20.8%)	8 (32%)	
– Perforated	16 (12.8%)	9 (36%)	
– Plastron	4 (3.2%)	1 (4%)	
– Peritonitis	9 (7.2%)	4 (16%)	
<b>Mean hospital stay</b>	3.79 ± 2.91	7 ± 4.23	p < 0.016*

\*Statistically significant.  
LT: laparotomy; LP: laparoscopy.

**Table II. Clavien-Dindo classification of surgical complications.**

<i>Grade</i>	<i>Definitions</i>
<b>I</b>	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 and electrolytes, and physiotherapy. This grade also includes wound infections opened at the bedside
<b>II</b>	Requiring pharmacological treatment with drugs other than such allowed for grade I complications. Blood transfusions and total parenteral nutrition are also included
<b>III</b>	Requiring surgical, endoscopic or radiological intervention.
– IIIa	Intervention not under general anesthesia
– IIIb	Intervention under general anesthesia
<b>IV</b>	Life-threatening complication (including brain hemorrhage, ischemic stroke, subarachnoidal bleeding) requiring IC/ICU management
– IVa	Single organ dysfunction (including dialysis)
– IVb	Multi organ dysfunction
<b>V</b>	Death of a patient
<b>“d” suffix</b>	Complications that have the potential for long-lasting disability after patient’s discharge are highlighted in the present classification by a suffix (“d” for disability). This suffix indicates that a follow-up is required to comprehensively evaluate the outcome and related long-term quality of life

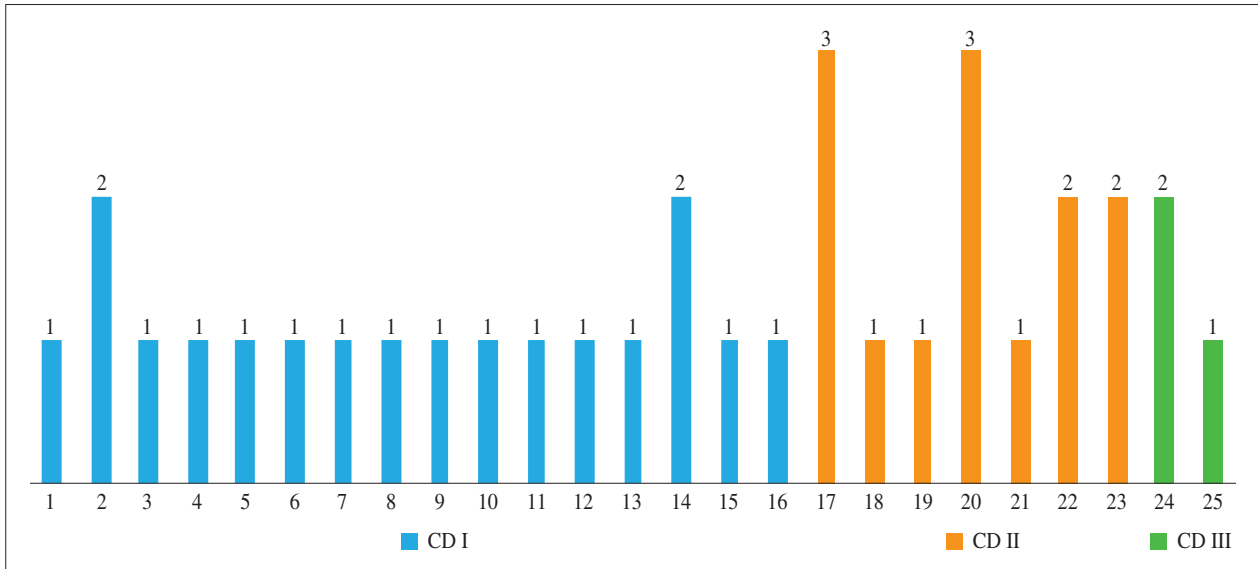
**Table III. Grading according to Clavien-Dindo classification, description of complications recorded, treatment, hospital stay, and re-admission.**

CD classification	Surgical approach	Intraoperative finding	Complication	Treatment	Hospital stay (days)	Re-admission
I	LT	P	15 mm collection	IV antibiotic*	7	No
I	LT	C p	25 mm collection at the scrotal sac Right epididymo-orchitis	Oral antibiotic Analgesics	5	No
I	LT	P	Non-infectious diarrhea	Fluid replacement therapy	7	No
I	LT	NC ph	22 mm collection	Oral antibiotic*	2	No
I	LT	NC ph	Fever	Antipyretics	4	No
I	LT	C g	Vomiting	Antiemetics	6	No
I	LT	C p	Vomiting	Antiemetics	5	No
I	LT	C p	Wound cellulitis Hydrocele	IV antibiotics*	10	No
I	LT	NC ni	Vomiting	Antiemetics	4	No
I	LP	C g	Vomiting	Antiemetics	4	No
I	LT	C p	Vomiting	Antiemetics	6	No
I	LT	Plastron	Fever	Antipyretics	8	No
I	LT	C p	Vomiting	Antiemetics	5	No
I	LP	C p	Pain Vomiting	Analgesics Antiemetics	6	No
I	LT	C g	Vomiting	Antiemetics	3	No
I	LT	C p	Vomiting	Antiemetics	6	No
II	LT	C p	27 mm collection Vomiting Pain	IV antibiotic Antiemetics Analgesics	8	No
II	LT	C g	Rhinovirus pneumonia	Antivirals	14	No
II	LP	C g	35 mm collection	IV antibiotic	11	No
II	LT	C g	30 mm collection Vomiting Pain	IV antibiotic Antiemetics Analgesics	3	Yes
II	LT	C g	Reduced diuresis	TPN Volume load	6	No
II	LT	P	25 mm collection Vomiting	IV antibiotic Antiemetics	15	No
II	LP	C g	Vomiting 70 mm collection	Antiemetics IV antibiotic	4	Yes
IIIb	LP	C p	110 mm collection Right pleural effusion	Surgical re-intervention for drainage	19	No
IIIb	LT	P	73 mm pelvic abscess	Surgical re-intervention for drainage	13	No

\*Same antibiotic treatment in accordance with the intra-operative finding protocol. LT: laparotomy; LP: laparoscopy; NC: non-complicated; ph: phlegmonous; ni: no inflammation; C: complicated; g: gangrenous; p: perforated; P: peritonitis; TPN: total parenteral nutrition; IV: intravenous.

belonged to the CD II group, and 2 cases belonged to the CD IIIb group. Of the total of patients with complications, 52% (13 patients) had vomiting – the most frequent complication; 2 patients required antipyretic treatment due to persistent fever; 4 patients required rescue analgesics in

spite of already being under analgesic treatment; and 10 patients had collection/intra-abdominal abscess. The latter were classified as CD I when antibiotic treatment remained unchanged from the postoperative protocol, CD II when the next step in antibiotic therapy had to be made, and CD



**Figure 1.** Number of complications per patient.

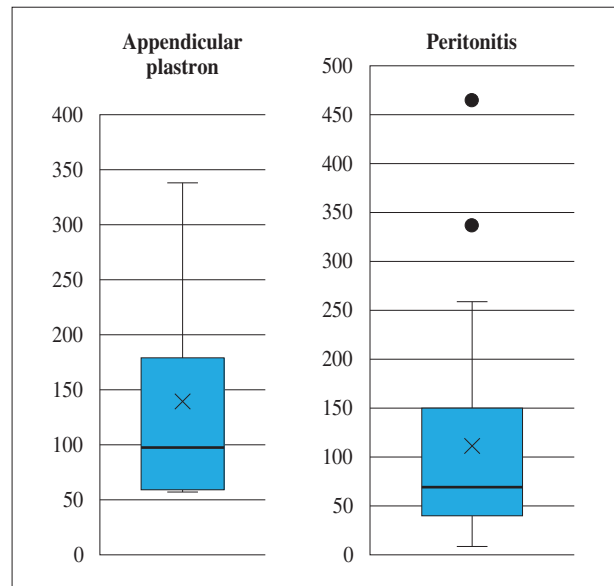
IIIb when surgical re-intervention under general anesthesia was required for drainage purposes.

In our series, complications such as surgical wound collection or intestinal occlusion/subocclusion, which have been described in the literature, were not recorded.

Figure 1 features the number of complications per patient. Of the patients who developed complications, 80% had been experiencing pain for more than 24 h. Surgical findings of these 25 children included complicated appendix in 17 patients, peritonitis in 4 patients, non-complicated appendix in 3 patients, and appendicular plastron in 1 patient – the latter was found intraoperatively. The main factors involved in complication occurrence were advanced appendicitis (88% were gangrenous appendicitis, perforated appendicitis, plastron appendicitis, and peritonitis) ( $p < 0.001$ ) and progression time (80% >24 h of progression) ( $p < 0.036$ ), which increased mean hospital stay by  $7 \pm 4$  days ( $p < 0.016$ ).  $137 \text{ mg/L} \pm 37 \text{ mg/L}$  CRP levels were associated with plastron identification ( $p < 0.001$ ), whereas  $109 \text{ mg/L} \pm 19 \text{ mg/L}$  CRP levels were associated with peritonitis ( $p < 0.001$ ) (Fig. 2). In 20% of patients, the approach was laparoscopic. No statistically significant relationship was found between complications and surgical approach, surgeon's experience, preoperative leukocyte or neutrophil count, or patient origin. 48% of surgical specimens were correlated both with the pathological analysis and surgical findings.

## DISCUSSION

Symptoms, clinical signs, and radiological findings of acute appendicitis are extremely variable, especially in



**Figure 2.** Box Plot with CRP levels ( $137 \pm 37$ ) for appendicular plastron ( $p < 0.001$ ) and CRP levels ( $109 \pm 19$ ) for peritonitis ( $p < 0.001$ ).

younger children (under 5 years of age), where non-specific symptoms and clinical signs, along with rapid disease progression and lack of communication with the patient, represent a true diagnostic and therapeutic challenge<sup>(19)</sup>.

Various studies demonstrate that younger children (0-4 years of age) tend to suffer from advanced appendicitis more often (OR (odds ratio): 4.9; 95% confidence interval (CI): 4.0-5.9) than adolescents<sup>(2,22,23)</sup>. Our series confirmed that the younger the age (<5 years old), the greater the risk



of advanced appendix – 80% higher than older children or adolescents (OR: 1.63; 95% CI: 1.33-2).

A complication is an unplanned result of the procedure which causes a deviation from the ideal postoperative course, involves a change of management, and requires additional interventions. Complications vary according to the surgeon's skills, procedure learning curve, patient comorbidity, and available facilities and resources. The incidence of postoperative complications remains the most frequent quality marker in surgery. However, there are no standard guidelines or criteria to report postoperative complications following appendectomy in-pediatric patients.

In our department, we have a standardized therapeutic protocol based on surgical findings<sup>(18)</sup>. However, identifying those patients who will subsequently develop complications is not an easy task. In our series, complication rate was 20%, without severe type IV (requiring IC/ICU-management) or type V (death of a patient) complications.

The laparoscopic approach has demonstrated certain advantages, such as less postoperative pain, smaller incisions, shorter hospital stay, quicker return to normal life, fewer surgical wound infections, and fewer postoperative adhesions, with a resulting decrease in postoperative complications<sup>(24,25)</sup>. However, in our series, the surgical approach had no association whatsoever with the occurrence of complications in the postoperative period.

In a retrospective review of 1,255 patients undergoing acute appendicitis surgery, even when appendectomy samples showed normal macroscopic characteristics, histopathological analyses were demonstrated to provide clinically useful information on patient condition and help improve patient result by revealing a previously unknown disease<sup>(26)</sup>. In a 69-patient series, a weak correlation between macroscopic diagnosis by the surgeon and pathological findings was found<sup>(27)</sup>. In our series, only complicated appendixes (gangrenous and perforated) were considered. Kappa coefficient showed a weak correlation between surgeon descriptions and pathological studies ( $k = 0.28$ ; 95% CI: 0.06-0.50), but this had no impact on complication occurrence ( $k = 0.07$ ; 95% CI: -0.05-0.20).

## CONCLUSION

The use of the Clavien-Dindo classification could consolidate criteria regarding complications following appendectomy, regardless of the surgical approach used. This would provide a standardized way of reporting postoperative complications.

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