

# Influence of overweight and obesity on acute appendicitis in children. A cohort study

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## ABSTRACT

**Introduction.** Overweight and obesity are risk factors for the development of postsurgical complications in acute appendicitis in adults. However, there are few studies that evaluate their effects in pediatric patients. We aim to analyze their influence on the postoperative course of acute appendicitis in children.

**Materials and methods.** A prospective cohort study was performed in patients undergoing surgery for acute appendicitis in 2017-2018, divided into two cohorts according to BMI adjusted to sex and age, following the WHO criteria: exposed cohort (overweight-obese) and non-exposed cohort (normal weight). Clinical follow-up was performed during hospital admission and one month after surgery. Demographic variables, operating time, average hospital stay, and early postoperative complications (wound infection, wound dehiscence, and intra-abdominal abscess) were assessed.

**Results.** A total of 403 patients were included (exposed cohort n=97 and non-exposed cohort n=306), with no differences in sex or age. A longer operating time was observed in the exposed cohort (57.6 ± 22.5 vs. 44.6 ± 18.2 min, p<0.001), with no differences found according to the surgical approach (open surgery or laparoscopic surgery) used. This group also had a higher surgical wound infection rate as compared to the non-exposed cohort (10.3% vs. 4.2%; RR: 1.90; CI: 95% [1.15-3.14], p<0.001), as well as a higher surgical wound dehiscence rate (7.2% vs. 2.3%; RR: 2.16; CI: 95% [1.24-3.76], p<0.001). No differences in the development of intra-abdominal abscesses or in hospital stay were observed.

**Conclusions.** Obese and overweight children with appendicitis have a higher risk of developing postoperative complications such as wound infection and dehiscence than normal weight patients.

**KEY WORDS:** Appendicitis; Pediatric obesity; Body mass index; Postoperative complications; Surgical wound infection.

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*Work presented at the 58th Congress of the Spanish Pediatric Surgery Society, May 2019. Vigo (Spain).*

*Date of submission:* May 2019

*Date of acceptance:* November 2019

## INFLUENCIA DEL SOBREPESO Y OBESIDAD INFANTIL EN LA APENDICITIS AGUDA EN NIÑOS. ESTUDIO DE COHORTES

### RESUMEN

**Introducción.** El sobrepeso y la obesidad constituyen factores de riesgo para el desarrollo de complicaciones postquirúrgicas en apendicitis aguda en adultos. Sin embargo, pocos estudios han evaluado sus efectos en pacientes pediátricos. Nuestro objetivo es analizar su influencia en el curso postoperatorio de la apendicitis aguda en niños.

**Material y métodos.** Estudio de cohortes prospectivo realizado en pacientes intervenidos de apendicitis aguda durante 2017-2018, distribuidos en dos cohortes según el IMC ajustado al sexo y edad de cada individuo siguiendo los criterios de la OMS: cohorte expuesta (sobrepeso-obesidad) y no expuesta (normopeso). Se evaluaron variables demográficas, tiempo quirúrgico, estancia media hospitalaria y complicaciones postoperatorias precoces (infección y dehiscencia de herida quirúrgica y absceso intraabdominal).

**Resultados.** Se incluyeron un total de 403 pacientes (cohorte expuesta n= 97 y cohorte no expuesta n= 306) sin diferencias en sexo y edad. La cohorte expuesta presentó un mayor tiempo quirúrgico (57,6 ± 22,5 minutos vs 44,6 ± 18,2 minutos; p< 0,001), sin diferencias en cuanto a la técnica quirúrgica realizada (abierto o laparoscópica). Este grupo presentó mayor tasa de infección de herida quirúrgica al compararla con la cohorte no expuesta (10,3% vs 4,2%; RR 1,90 IC95% [1,15-3,14]; p<0,001), así como una mayor tasa de dehiscencia de herida quirúrgica (10,3% vs 2,3%; RR 2,16 IC95% [1,24-3,76]; p<0,001). No se observaron diferencias en el desarrollo de abscesos intraabdominales ni en la estancia media hospitalaria.

**Conclusiones.** El sobrepeso y obesidad infantil constituyen un factor de riesgo para el desarrollo de complicaciones postoperatorias en la apendicitis aguda, como infección y dehiscencia de la herida quirúrgica.

**PALABRAS CLAVE:** Apendicitis; Obesidad infantil; Índice de masa corporal; Complicaciones postoperatorias; Infección herida quirúrgica.

## INTRODUCTION

It is well acknowledged that overweight and obesity are risk factors in adult patients, associated with numerous

potential comorbidities, including respiratory disorders, high blood pressure, and diabetes<sup>(1)</sup>. Surgical procedures in these patients tend to be more complex owing to their greater technical and anesthetic difficulty, since anatomical references are more difficult to visualize, difficult airway is more frequent, and aspiration risk is higher due to a greater gastric residual volume<sup>(2)</sup>. In addition, the excess of visceral adipose tissue in these patients brings about a pro-inflammatory status which causes metabolic alterations that may impact postoperative immune response and explain some postsurgical complications<sup>(3)</sup>.

Numerous studies have demonstrated a higher incidence of postsurgical complications in obese patients, such as surgical wound infection and dehiscence<sup>(4)</sup>, as well as increased mean hospital stay<sup>(5)</sup>. This impact on comorbidity has been studied in various surgical pathologies, such as acute appendicitis, since it is the most frequent surgical emergency in all age and sex groups<sup>(6)</sup>.

However, the literature about overweight and obesity effects in pediatric abdominal surgery is scarce as compared to that about adult patients. Few studies have assessed the relationship between body mass index (BMI) and postoperative complications in pediatric patients, sometimes with little conclusive results<sup>(7)</sup>, and barely applicable to other patients due to the sample's size<sup>(8)</sup>. In addition, most studies are retrospective, with no prospective studies found in the literature reviewed up until now, which makes it difficult to extrapolate the results achieved. Furthermore, complication rates in children are low, so more extensive studies are required to note any potential difference<sup>(9)</sup>.

The objective of this study is to analyze overweight and obesity's influence on acute appendicitis in children, so as to quantitatively analyze their effect on clinical course and postsurgical complications.

## MATERIALS AND METHODS

A prospective cohort study was carried out in patients undergoing surgery for acute appendicitis in our healthcare facility between January 2017 and December 2018. The BMI of each patient was calculated by dividing weight – in kilograms – by size squared – in meters ( $BMI = \text{weight}[\text{kg}] / \text{size}[\text{m}]^2$ ). Patients were distributed in two cohorts according to BMI adjusted to the sex and age of each subject using the World Health Organization's criteria: an exposed cohort, made up of patients with overweight-obesity at admission, and a non-exposed cohort, made up of patients with normal weight at admission.

Demographic variables (age and sex), evolution time (hours), surgical approach (open or laparoscopic), operating time (minutes), intra-operative diagnosis (phlegmonous acute appendicitis, gangrenous acute appendicitis, peritonitis, white acute appendicitis), mean hospital stay (days),

and early postsurgical complications, defined according to the USA Centers for Disease Control and Prevention's criteria<sup>(10)</sup> – surgical wound infection (any infection associated with the surgical procedure developing at the incision or its surroundings during the first 30 postoperative days), surgical wound dehiscence (any opening of the surgical incision not complying with surgical wound infection criteria), and intra-abdominal abscess (presence of purulent material within the abdominal cavity) – were assessed.

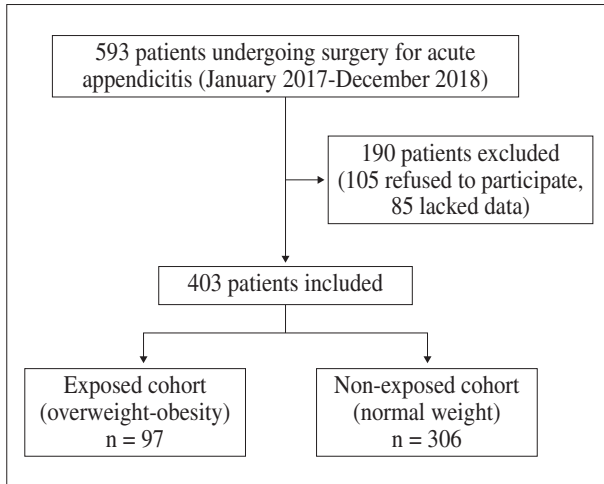
All patients undergoing surgery for acute appendicitis over that period who voluntarily accepted to participate in the study and those whose legal representatives' authorization was obtained were included. Exclusion criteria were denial to participate in the study and lack of data regarding any of the variables studied. Follow-up during admission in the study patients was carried out, with a subsequent external check-up one month following the surgical procedure.

Regarding the statistical analysis, continuous variables were expressed as mean and standard deviation. In order to check whether variables were normally distributed or not, Kolmogorov-Smirnoff and Shapiro-Wilk tests were used. For normally distributed continuous variables, a T of Student test of independent samples was carried out, and for non-normally distributed continuous variables, the Mann-Whitney test was used. Discrete variables were expressed as frequency and percentage, and they were analyzed using the Chi square test – or the Fisher test when the first could not be used. Relative risks (RR) were calculated with 95% confidence intervals. All statistical calculations were performed using two-tailed tests, statistical significance being established with a  $p < 0.05$  value. Data were collected using Microsoft Excel, version 2010 (Redmond, WA, USA), and analyzed using SPSS Statistic, version 22 (Chicago, IL, USA).

## RESULTS

Over the 2017-2018 period, a total of 598 patients with acute appendicitis were operated on in our healthcare facility, 403 of whom were eventually included in the study, with a median follow-up of 30 days post surgical procedure. 97 were included in the exposed cohort (overweight-obesity), and 306 in the non-exposed cohort (normal weight). Figure 1 features the flow diagram of study patients. Table 1 features the demographic characteristics of both groups.

No differences in clinical evolution time between groups were noted. However, the exposed cohort had longer operating times ( $57.6 \pm 22.5$  minutes vs.  $44.6 \pm 18.2$  minutes;  $p < 0.001$ ), with the laparoscopic approach being more frequently used than in the non-exposed cohort ( $54.6\%$  vs.  $22.5\%$ ;  $p < 0.001$ ). No differences in intra-operative diagnosis between groups were observed. Mean



**Figure 1.** Flow diagram.

hospital stay was longer in the exposed cohort ( $3.6 \pm 2.8$  days vs.  $3.2 \pm 2.9$  days), with no statistically significant differences between groups ( $p = 0.344$ ). Table 2 features the clinical and intra-operative characteristics.

Regarding postsurgical complications, overweight and obese patients had a higher surgical wound infection rate as compared to normal weight patients (10.3% vs. 4.2%; RR: 1.90; CI: 95% [1.15-3.14];  $p < 0.001$ ), as well as a higher surgical wound dehiscence rate (7.2% vs. 2.3%; RR: 2.16; CI: 95% [1.24-3.76];  $p < 0.001$ ). Intra-abdominal abscess occurrence was similar in both groups, with no

**Table 1.** Demographic characteristics.

	Overweight-Obesity (n = 97)	Normal weight (n = 306)	p value
Age	10.1 $\pm$ 3.2	10.1 $\pm$ 3.2	0.945
Sex			
Male	64 (66%)	185 (60.5%)	0.329
Female	33 (34%)	121 (39.5%)	

significant differences (5.2% vs. 5.3%;  $p = 0.97$ ). When performing a group stratification according to the surgical approach used – open or laparoscopic appendectomy –, no significant differences were found in the incidence of these complications, as demonstrated in Table 3, which features complications after open appendectomy, and in Table 4, which features complications after laparoscopic appendectomy.

## DISCUSSION

Our study demonstrated longer operating times and a longer hospital stay in overweight and obese patients undergoing surgery for acute appendicitis, as well as a higher surgical wound infection and dehiscence rate as compared to normal weight patients.

These results are similar to those achieved by Davies et al., who retrospectively analyzed 282 patients with acute appendicitis, and observed that obese children required

**Table 2.** Clinical and intra-operative characteristics.

	Overweight-Obesity (n = 97)	Normal weight (n = 306)	p
Evolution time (hours)	26.84 $\pm$ 28.62	28.29 $\pm$ 27.34	0.176
Operating time (minutes)	57.57 $\pm$ 22.53	44.60 $\pm$ 18.19	<0.001
Intra-operative diagnosis			
• Phlegmonous	58 (59.8%)	188 (61.5%)	0.770
• Gangrenous	33 (34.1%)	78 (25.5%)	0.512
• Peritonitis	4 (4.1%)	35 (11.4%)	0.054
• White	2 (2%)	5 (1.6%)	0.873
Hospital stay (days)	3.43 $\pm$ 2.75	3.29 $\pm$ 2.87	0.344

**Table 3.** Postsurgical complications stratified according to the surgical approach used. Open appendectomies.

	Overweight-obesity (n = 53)	Normal weight (n = 237)	p	RR (CI: 95%)
Surgical wound infection	5 (9.4%)	10 (4.2%)	0.248	2.24 (0.80-6.27)
Surgical wound dehiscence	4 (7.5%)	5 (2.1%)	0.327	3.58 (0.99-12.87)
Intra-abdominal abscess	3 (5.7%)	13 (5.5%)	0.082	1.03 (0.30-3.76)

**Table 4. Postsurgical complications stratified according to the surgical approach used. Laparoscopic appendectomies.**

	<i>Overweight-obesity (n = 44)</i>	<i>Normal weight (n = 69)</i>	<i>p</i>	<i>RR (CI: 95%)</i>
<b>Surgical wound infection</b>	5 (11.4%)	3 (4.3%)	0.252	2.61 (0.66-10.39)
<b>Surgical wound dehiscence</b>	3 (6.8%)	2 (2.9%)	0.355	2.35 (0.41-13.52)
<b>Intra-abdominal abscess</b>	2 (4.5%)	3 (4.3%)	0.233	1.05 (0.18-6.01)

longer operating times and a longer hospital stay<sup>(5)</sup>. Witt et al. noted a higher frequency in the occurrence of postsurgical complications with BMI increases (4.5% in normal weight patients, 5.3% in overweight patients, 5.7% in obese patients, and 7.3% in morbid obesity patients;  $p = 0.014$ )<sup>(9)</sup>. The multivariate analysis demonstrated a quadratic relationship between BMI percentile and increased frequency of surgical wound infection, unscheduled tracheal intubation, and longer operating times.

In our series, BMI does not seem to impact acute appendicitis evolution times or intra-operative diagnosis. These results are consistent with those achieved by Timmerman et al., who analyzed 457 patients undergoing surgery for acute appendicitis classified according to BMI, with no differences in intra-operative appendicular involvement<sup>(11)</sup>. Obese patients had longer hospital stays and more postsurgical complications, although not statistically significant probably due to the small sample size of obese patients.

Our study is the first to quantify overweight and obesity effects on postsurgical complications, with the relative risk of developing surgical wound infection or dehiscence doubling as compared to normal weight patients. These data are similar to those achieved by Blackwood et al., who analyzed 1,380 surgical wound infections in 66,671 pediatric patients undergoing surgery, and noted a higher prevalence in overweight and obese patients<sup>(12)</sup>. Pediatric general surgery (3.6%) and cardiothoracic surgery (2.5%) had the highest rates of surgical wound infection, with appendectomy being the most commonly associated procedure.

Recently, Michailidou et al. studied postsurgical complications after laparoscopic appendectomy in 2,812 pediatric patients in the National Program for Pediatric Surgical Quality Improvement's set of data<sup>(13)</sup>. When comparing obese patients with non-obese patients, no differences in the development of complications were found, but obese patients required longer operating times. These results are similar to those from our study, where the stratified analysis according to the surgical approach used did not find any differences regarding complications between laparoscopic appendectomies in both groups.

Garey et al. compared the occurrence of intra-abdominal abscess in patients undergoing surgery for appendicular peritonitis, the proportion being largely higher in obese

patients – up to 35% vs. 15% in normal weight patients<sup>(8)</sup>. In our study, no differences in the development of intra-abdominal abscess between groups were noted, probably due to the low level of occurrence. The results from our study demonstrate that overweight and obesity have a negative impact on surgical patients, so pediatric surgeons should be aware of and try to minimize them.

Our study does have one limitation – the reduced participation of patients diagnosed with acute appendicitis in our healthcare facility between 2017 and 2018, with a final inclusion rate of 67% of the total of patients undergoing surgery over that period of time. The primary reason for this is parents refused to let their children participate in the study.

In conclusion, this is the first prospective study allowing overweight and obesity's impact on acute appendicitis' clinical course and postsurgical complications to be quantified. Therefore, it can help implement preventive measures regarding increased obesity in the pediatric population.

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