Pediatric Surgery International (2023) 39:90
https://doi.org/10.1007/s00383-023-05369-2

ORIGINAL ARTICLE

Does the timing of appendectomy affect outcomes and postoperative complications?

María San Basilio[1] · Carlos Delgado-Miguel[1] · Carla Ramírez-Amorós[1] · María Sarmiento[1] · Lucas Moratilla-Lapeña[1] · Arturo Almeyda[1] · Ricardo Mejía[1] · Leopoldo Martínez[1]

Accepted: 26 November 2022 / Published online: 25 January 2023

Abstract

Purpose There is controversy about the necessity of nighttime appendectomy. The aim of this study was to determine whether timing of appendectomy performance plays a role on postoperative complications.

Methods A retrospective single-center comparative study was performed in children who underwent surgery for acute appendicitis between 2017 and 2021. Patients were divided into groups based on the time slot in which surgery was performed: morning (8:00 h–15:00 h), afternoon (15:00 h–22:00 h) and night (22:00 h–08:00 h). Demographics, intraoperative data, length of hospital stay, and postoperative complications were analyzed and compared.

Results A total of 1643 patients were included: 337 were operated in the morning, 751 in the afternoon and 555 at night. We found no demographic differences. When comparing the intraoperative data, no differences were observed in the percentage of complicated appendicitis. Night group patients presented a higher percentage of open appendectomies (64.5%) when compared to afternoon (49.6%) and morning (46.2%) groups ($p < 0.001$). Surgery time was also significantly shorter in the night group (45.2 min ± 18.9 min) ($p < 0.001$). There were no differences in length of hospital stay, postoperative complications rate or readmission rate.

Conclusion These results show that in our institution time slot in which the appendectomy is performed has no consequences in postoperative outcomes and complications.

Keywords Acute appendicitis · Appendectomy · Nighttime surgery · Emergency

Introduction

In recent years, there has been controversy surrounding the need for performing certain urgent surgeries at night or whether it is safer to wait until the next morning [1, 2]. Working as an on-call physician causes fatigue and sleep deprivation, which is applicable for both residents and consultants, therefore at night surgical complications may take place [2]. While some studies have linked night-time surgery to increased morbidity and error rates, other studies that looked at this effect found no evidence of increased morbidity [3, 4].

Acute appendicitis (AA) is the most common cause of acute abdomen in children with an incidence in life of 8.6% in men, and 6.9% in women [5] and surgery is the standard treatment. Due to its high incidence in pediatric age, appendectomies are the most frequent surgery for on-call pediatric surgeons. Recently the question has arisen as to whether this surgery should be emergent or urgent, with a majority of studies demonstrating that it is safe to wait up to 16–24 h until surgery once intravenous antibiotic therapy is initiated [6]. This creates the possibility of ruling out overnight surgery and leaving appendectomies in a standardized manner until the next morning, which can be problematic in high-volume hospitals where free operating rooms during the morning shift are scarce.

The aim of this study was to analyze how the time slot in which appendectomies were performed correlated with complication rates.

✉ María San Basilio
mariacarmen.sanbasilio@salud.madrid.org

[1] Department of Pediatric Surgery, La Paz Children's Hospital, Paseo de la Castellana 261, 28046 Madrid, Spain

Methods

Study design

A retrospective single-center comparative study was performed in children who underwent surgery for acute appendicitis (AA) in a tertiary university hospital. We divided patients into three groups based on the time slot in which they had been operated on: morning (8:00 h–15:00 h), afternoon (15:00 h–22:00 h) and night (22:00 h–08:00 h). This type of division was decided taking into account the work schedules of nursing and other health personnel, that change shifts at 15:00 h, 22:00 h and 8:00 h.

Patient selection

All patients under 16 years of age with AA diagnosis who underwent appendectomy in our hospital between January 2017 and December 2021 were considered for inclusion in the study. Patients in whom conservative management with intravenous antibiotic therapy was initially chosen and delayed appendectomy performed were excluded, as well as those who underwent prophylactic appendectomy in the context of another surgical procedure. Patients whose data about time of the surgery were missing were also excluded.

Study variables

Demographics (age, gender and body mass index), clinical characteristics such as time since symptoms onset, intraoperative data and postoperative complications such as surgical site infection (SSI), surgical wound dehiscence, intestinal obstruction, intraabdominal abscess or postoperative fever were analyzed and compared between groups. Intra-operative diagnosis was divided into negative appendicitis, phlegmonous appendicitis, gangrenous appendicitis or periappendicitis. We also evaluated extended hospital stays due to complications and readmission rates. Surgical reports expressing any intraoperative surgical complication (conversion to open surgery, bleeding, damage to vital organs, etc.) were noted.

Preoperative management

In all cases, an abdominal ultrasound was performed and confirmed the diagnosis. All patients received the same antibiotic treatment, according to our institution's protocol, in consensus with the Preventive Medicine Service. Preoperatively, a single dose of Amoxicillin–Clavulanic acid (40 mg/kg, maximum dose 2 g) was administered to all patients when the diagnosis of AA was confirmed by ultrasound. Intraoperative diagnosis determined postoperative antibiotic management and hospital stay. After surgery, antibiotic was only continued in gangrenous appendicitis (Amoxicillin–Clavulanic Acid for 5 days), and in appendicitis complicated by peritonitis or appendicular mass (Gentamicin, Metronidazole and Amoxicillin–Clavulanic Acid for 7 days).

Data collection

Data collection was carried out anonymously and confidentially without data that allows each patient to be subsequently identified. Ethical committee approval was not required due to the retrospective nature of this study, the absence of human samples and the anonymous collection of analytical data, and in accordance with the local legislation and national guidelines.

Statistical analysis

Statistical analysis was performed using SPSS Statistics version 22.0 (IBM, Armonk, NY, USA). To compare quantitative variables, after a normality study, the ANOVA test (in variables with normal distribution) or the Kruskal–Wallis test (in variables that did not follow a normal distribution) was applied. Discrete variables were expressed as frequency and percentage, and were analyzed using the Chi square test. Odds ratios (OR) with 95% confidence intervals were calculated. Statistical significance was established with a p value of < 0.05.

Results

A total of 1643 patients (1006 men and 637 women [58.8% vs 41.2%]) were included, with a mean age at diagnosis of 10.3 ± 3.4 years. A total of 24 Patients with initially considered for the study were excluded. No significant differences were observed in terms of distribution according to sex ($p = 0.237$), age ($p = 0.213$), weight ($p = 0.235$) or time since symptoms onset ($p = 0.466$) when comparing the three groups. Demographics are shown in Table 1.

Regarding intraoperative features, the distribution according to the type of appendicitis was similar in the three groups, with non-complicated appendicitis with a phlegmonous appendix being the most observed in all groups: 193 cases (57.3%) in morning group, 438 cases (58.3%) in afternoon group and 314 cases (56.6%) in night group ($p = 0.339$). The type of surgical approach varied between groups, being the laparoscopic appendectomy the more frequent technique in morning and afternoon groups, and open appendectomy the more frequent in night group (morning: 170 laparoscopic (50.4%) vs 167 open (49.6%),

Table 1 Demographic features

	Morning	Afternoon	Night	*P* value
Gender; *n* (%)				
Male	139 (41.2%)	298 (39.7%)	200 (36%)	0.237
Female	198 (58.8%)	453 (60.3%)	355 (64%)	
Age (years); mean ± SD	10.1 ± 3.3	10.5 ± 3.3	10.3 ± 3.4	0.213
Weight (kg); mean ± SD	37.3 ± 15.4	39.3 ± 21.8	38.3 ± 15	0.235
BMI (Kg/m^2); mean ± SD	18.3 ± 3.8	19.4 ± 12.4	18.5 ± 3.5	0.214
Time since symptoms onset (hours); median (Q1–Q3)	24 (12–36)	24 (12–36)	24 (12–42)	0.466

SD, standard deviation.

Q1–Q3, interquartile range

Table 2 Intraoperative features

	Morning	Afternoon	Night	*P* value
Type of appendicitis; *n* (%)				
White	6 (1.8%)	16 (2.1%)	4 (0.7%)	0.339
Phlegmonous	193 (57.3%)	438 (58.3%)	314 (56.6%)	
Gangrenous	80 (23.7%)	171 (22.8%)	149 (26.8%)	
Peritonitis	58 (17.2%)	126 (16.8%)	88 (15.9%)	
Surgical approach; *n* (%)				
Laparoscopic	170 (50.4%)	404 (53.8%)	197 (35.5%)	< 0.001
Open	167 (49.6%)	347 (46.2%)	358 (64.5%)	
Surgical time (min); mean ± SD	49.4 ± 21.7	50.6 ± 20.8	45.2 ± 18.9	< 0.001

SD standard deviation

afternoon: 404 laparoscopic (53.8%) vs 347 open (46.2%) and night: 197 laparoscopic (35.5%) vs 358 open (64.5%); $p < 0.001$). The surgical time also varied between groups, with statistically significant differences between them. The mean surgical time was 49.4 ± 21.7 min in morning group, 50.6 ± 20.8 min in afternoon group and 45.2 ± 18.9 min in night group ($p < 0.001$). When comparing surgical time in laparoscopic surgery vs open surgery regardless of the time of the day the surgery was performed, the differences were statistically significant, with a mean time of surgery of 55.5 ± 22.0 min for laparoscopic appendectomy and 42.3 ± 16.8 min for open appendectomy ($p < 0.001$). Table 2 shows intraoperative features compared in the three groups.

Length of hospital stay was similar in the three groups, with a mean of 3.9 ± 4 days in morning group, 3.4 ± 4.5 days in afternoon group and 3.4 ± 7.7 days in night group ($p = 0.467$). There was no statistically significant difference between postoperative complication rates in the three groups (1.8% in morning group, 3.1% in afternoon group and 1.6% in night group). Intraabdominal abscess was the most common complication, which was observed in 116 patients (7.1%), with no differences between groups ($p = 0.088$). Surgical site infection (SSI) was diagnosed in 63 patients (3.83%), of whom 11 belonged to the morning group, 30 to the afternoon group and 22 to the night group ($p = 0.829$). Readmission was required in 66 patients (4.0%) and an extended admission due to complications was needed in 75 patients (4.6%), with no statistically significant differences between the three groups in these two aspects. Postoperative features are shown in Table 3.

Table 3 Postoperative features

	Morning	Afternoon	Night	*P* value
Hospital stay (days); median (Q1–Q3)	2 (1–6)	2 (1–4)	2 (1–4)	0.467
Postoperative complications; *n* (%)	38 (11.3%)	101 (13.4%)	59 (19.6%)	0.264
Type of complication; *n* (%)				
Intraabdominal abscess	24 (7.1%)	63 (8.4%)	29 (5.2%)	0.243
Surgical site infection (SSI)	11 (3.3%)	30 (4%)	22 (4%)	0.829
Wound dehiscence	6 (1.8%)	23 (3.1%)	10 (1.8%)	0.074
Fever	5 (1.5%)	10 (1.3%)	9 (1.6%)	0.910
Intestinal obstruction	4 (1.2%)	15 (2%)	3 (0.5%)	0.088
Readmission rate; *n* (%)	11 (3.3%)	35 (4.7%)	20 (3.6%)	0.461
Prolonged admission; *n* (%)	15 (4.5%)	40 (5.3%)	20 (3.6%)	0.335

SD standard deviation, *Q1–Q3* interquartile range

All patients received a preoperative antibiotic regimen according to the protocol of our hospital with intravenous Amoxicillin—Clavulanic acid. When more than 8 h passed waiting for the intervention, the dose was repeated.

Discussion

This study analyzes the postoperative outcomes in children who underwent appendectomy for acute appendicitis according to the time of the intervention (morning, afternoon or night), without identifying differences in postoperative complications, hospital stay, readmission rate or prolonged hospitalization.

For years there has been discussion about whether pathologies that are not emergencies should be operated on at night. Timing of appendectomies, for its high incidence, has been one of the main sources of controversy and professionals have still not found an agreement. Those who defend operating at night justify it in that this way the shorter delay may increase patient comfort, reduce hospital stay, and decreases costs [7].This specially applies in environments with difficult daytime operating schedules [8]. Those who advocate for delaying surgery until daytime argue that it is safe to wait up until 8 h if antibiotic therapy is promptly started and by not operating at night mistakes due to fatigue or health workers are avoided. Some studies have shown a higher incidence of surgical site infection in patients operated on during nighttime [9].

In this large single-center study we have analyzed 1643 patients with appendicitis operated on in the last 5 years, divided according to the time slot in which they were operated on with the aim of comparing postoperative outcomes. Surgery was always performed by a junior surgeon (resident) helped by a senior surgeon (consultant). We made the following observations: first, risks of postoperative morbidity were similar among patients who underwent night surgery compared with day surgery. Second, an open approach was preferred in those patients undergoing surgery at night and surgeries tended be significantly shorter. According to these findings, night-time surgery for acute appendicitis has no impact on appendectomy complication rates. This is in line with the findings of several similar studies that report no correlation between nighttime surgery and postoperative complications [1, 10].

Those who advocate deferring surgery to the next day argue that it is safe to wait up to 24 h to operate on appendicitis as long as adequate antibiotic treatment is given [11]. They defend that this allows a calmer study of the pathology and thus reduces the number of negative appendectomies [12], on top of allowing a proper night rest for surgeons and anesthesiologists. Some studies have shown a higher incidence of intraoperative complications due to anesthesia mismanagement [11]. However, in our study no differences were observed in infections or anesthetic complications, nor in the incidence of negative appendectomies.

Waiting until the next morning to operate is consider safe in most cases, but cannot be applied for complicated appendicitis. This was laid out in the WSES Jerusalem Guidelines that were updated in 2020 and suggest against delaying appendectomy for pediatric patients with uncomplicated acute appendicitis needing surgery beyond 24 h from the admission. Early appendectomy within 8 h should be performed in case of complicated appendicitis [13]. This may leave the door open for deferring nighttime appendectomy until the next morning. The problem arises in hospitals with a large surgical volume, where it is difficult to find a free operating room in the morning. It is not uncommon that the urgent surgery may have to wait until the scheduled surgeries are finished, and this may translate to too much delay according to the literature results [14].

As for open appendectomy being the most used technique at night and the shorter surgical time at night, it must be understood that they are two related parameters, since in our series open appendectomy is significantly faster than laparoscopic. Although the differences in our study were statistically significant the actual difference of 5 min is not clinically significant and does not explain the election of a certain technique by the on-call team. The choice of laparoscopic versus open surgery is made by the consultant. It is based on the characteristics of the patient and the preferences of the surgeon. Our impression is that at the beginning of the study (which extends over 5 years) part of the surgical team and the OR team were somewhat more reluctant to laparoscopic surgery, considering it more complex and time-consuming and therefore at night they may have raised more opposition. Currently the laparoscopic approach is widely accepted, what was evidenced in the shift in preferences when we analyzed the data by years, seeing that in the last year of the study (2021) the most used approach at night was the laparoscopic one (73 vs 42).

There are no differences in postoperative results in this group of patients when compared to children operated on in the morning and afternoon, where there is a higher rate of laparoscopic appendectomies.

An important issue in studies comparing nighttime surgery to daytime surgery is selection bias, since clinically ill patients are more likely to have complicated appendicitis and more likely to be operated on earlier. On top of that there is the issue of delayed diagnosis, since in most centers, if the patient is stable, echography for patients attending the emergency room at late hours is not performed until the next morning. More symptomatic patients will have a prompter diagnosis even if it is the middle of the night and have a higher chance of having complicated appendectomy and

associated complications [15]. In our center, we have an on call radiologist and the ability to perform an echography at any time, thus we do not have the issue of delayed diagnosis.

This study has limitations that should be noted, mainly related to the retrospective and single-center design. However, the large sample size allows obtaining results with acceptable statistical power to extrapolate them to the general population. In our center, there is a high rate of nocturnal appendectomies due to the high occupancy of the emergency operating room during the morning, which can be a differentiating factor with other centers. For this reason, prospective randomized studies are necessary to reduce these potential biases.

Conclusion

In our local setting, nighttime surgery for AA is a safe practice that does not carry a higher risk of complications and should not be neglected. Decision on whether to operate at late hours should be made taking into account operating room availability on the following morning and in case of high chances of further delay until the afternoon, choose to operate at night.

Author contributions All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by MSB and CD-M. The first draft of the manuscript was written by María San Basilio and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

Data availability The data that support the findings of this study are available from the corresponding author upon reasonable request.

Declarations

Conflict of interest None declared.

References

1. Kelz RR, Tran TT, Hosokawa P, Henderson W, Paulson EC, Spitz F et al (2009) Time-of-day effects on surgical outcomes in the private sector: a retrospective cohort study. J Am Coll Surg 209:434–45.e2. https://doi.org/10.1016/j.jamcollsurg.2009.05.022
2. Landrigan CP, Rothschild JM, Cronin JW, Kaushal R, Burdick E, Katz JT et al (2004) Effect of reducing interns' work hours on serious medical errors in intensive care units. N Engl J Med 351:1838–1848. https://doi.org/10.1056/NEJMoa041406
3. Yaghoubian A, Kaji AH, Ishaque B, Park J, Rosing DK, Lee S et al (2010) Acute care surgery performed by sleep deprived residents: are outcomes affected? J Surg Res 163:192–196. https://doi.org/10.1016/j.jss.2010.04.011
4. Hall AB, Freeman T, Banks S (2011) Is it safe? Appendectomies at night at a low-volume center. J Surg Educ 68:199–201. https://doi.org/10.1016/j.jsurg.2010.12.001
5. Humes DJ, Simpson J (2006) Acute appendicitis. BMJ 333(7567):530–534. https://doi.org/10.1136/bmj.38940.664363.AE
6. Muñoz-Serrano AJ, Delgado-Miguel C, NúñezCerezo V, BarrenaDelfa S, Velayos M, Estefanía-Fernández K et al (2020) Does time to antibiotic initiation and surgery have an impact on acute appendicitis results? Cir Pediatr 33(2):65–70
7. Sartelli M, Viale P, Catena F, Ansaloni L, Moore E, Malangoni M et al (2018) 2013 WSES guidelines for management of intra-abdominal infections. World J Emerg Surg 8(3):1749–1778. https://doi.org/10.1186/1749-7922-8-3
8. Taylor M, Emil S, Nguyen N, Ndiforchu F (2005) Emergent vs. urgent appendectomy in children: a study of outcomes. J Pediatr Surg 40:1912–1915. https://doi.org/10.1016/j.jpedsurg.2005.08.005
9. Lee JM, Kwak BS, Park YJ (2018) Is a one night delay of surgery safe in patients with acute appendicitis? Coloproctology 34(1):11–15. https://doi.org/10.3393/ac.2018.34.1.11
10. Kelz RR, Freeman KM, Hosokawa PW, Asch DA, Spitz FR, Moskowitz M et al (2008) Time of day is associated with postoperative morbidity: an analysis of the national surgical quality improvement program data. Ann Surg 247:544–552. https://doi.org/10.1097/SLA.0b013e31815d7434
11. Huang L, Yin Y, Yang L, Wang C, Li Y, Zhou Z (2017) Comparison of antibiotic therapy and appendectomy for acute uncomplicated appendicitis in children a meta- analysis. JAMA Pediatr. 171:426–434. https://doi.org/10.1001/jamapediatrics.2017.0057
12. Tago T, Shimoda M, Imazato R, Udou R, Katsumata K, Tsuchida A, Suzuki S (2022) Possibility for avoidance of urgent nighttime operations for acute appendicitis in a regional core university hospital. Asian J Endosc Surg 15(1):22–28. https://doi.org/10.1111/ases.12953
13. Di Saverio S, Podda M, De Simone B, Ceresoli M, Augustin G, Gori A et al (2020) Diagnosis and treatment of acute appendicitis: 2020 update of the WSES Jerusalem guidelines. World J Emerg Surg. 15(1):27. https://doi.org/10.1186/s13017-020-00306-3
14. Pocard M, Pautrat K (2018) Yes, there is still a place for on-call nighttime surgery for acute appendicitis! J Visc Surg. 155(1):1–3. https://doi.org/10.1016/j.jviscsurg.2017.10.005
15. Frongia G, Mehrabi A, Ziebell L, Schenk JP, Günther P (2016) Predicting postoperative complications after pediatric perforated appendicitis. J Invest Surg 29(4):185–194. https://doi.org/10.3109/08941939.2015.1114690