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ORIGINAL ARTICLE

Impact of the coronavirus SARS-CoV-2 pandemic on the presentation and management of acute appendicitis in children

Impacto de la pandemia por coronavirus SARS-CoV-2 en la presentación y manejo de la apendicitis aguda en niños

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What do we know about the subject matter of this study?

The COVID-19 pandemic and confinement slowed surgical processes, delaying medical consultation and impacting the volume, diagnosis, and management of patients with acute appendicitis, affecting the incidence of complications and morbidity in this period.

What does this study contribute to what is already known?

During the pandemic, there was a significant increase in the time of progression to consultation, greater use of laparoscopy, more admissions to the critical care unit, and the hospital stay of the appendicular mass group was longer.

Abstract

Acute appendicitis (AA) is the most frequent cause of acute surgical abdomen in pediatrics. During the COVID-19 pandemic, lockdown slowed surgical processes, delaying medical consultations. **Objective:** To analyze the impact of the pandemic on the presentation and management of acute appendicitis. **Patients and Method:** Retrospective cohort, which included patients under 15 years of age seen in the emergency department (ED) with a diagnosis of acute appendicitis, from March to December of the pre-pandemic period of 2018 and the pandemic period in 2020. Demographic data, symptoms, treatment, and complications were analyzed. Patients were divided into groups based on the severity of the condition. A statistically significant difference of $p < 0.05$ was demonstrated. **Results:** 629 patients with AA from both periods were included. The evolution time from the onset of symptoms to the consultation of all patients with AA in the pandemic was longer, with 41.2 hours versus 35.5 hours in the pre-pandemic period ($p < 0.05$), and in the subgroup of complicated acute appendicitis (CAA), it was 59.5 hours versus 45.4 hours in the pandemic and pre-pandemic periods ($p < 0.01$), respectively. Admission to the intensive care unit was higher in the pandemic, with 3.9% versus 0.6% in the pre-pandemic period ($p < 0.05$). In the case of appendicular phlegmon, it had greater hospital stay in the pandemic with 11.6 days versus 7.8 days in the pre-pandemic period

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($p < 0.05$) and longer antibiotic treatment with 17 days in the pandemic versus 11.1 days in the pre-pandemic period ($p < 0.05$). The surgical approach in the pandemic was mainly laparoscopic with 62.4% ($p < 0.001$). **Conclusion:** During the pandemic, there was a delay in consultation and a greater requirement for intensive management in patients with acute appendicitis. The hospital stays and antibiotic treatment of appendiceal phlegmon were longer and the laparoscopic technique was the surgical approach of choice.

Introduction

Acute appendicitis (AA) is the first cause of acute surgical abdomen in children older than 2 years, representing 8% of consultations due to abdominal pain in emergency departments[1]. The delay in its diagnosis and surgical intervention is associated with an increase in the rate of complications such as peritonitis, abscess, or appendicular mass, which significantly increases morbidity and mortality and hospital costs[2].

The rate of appendiceal perforation is inversely proportional to age, ranging from 47.3% in children 5 years old to 100% in children under 2 years old[3]. It is directly related to the time of progression before surgery, and the delay in its surgical resolution is more associated with out-of-hospital delays than in-hospital ones[4]. Different factors in children contribute to late diagnosis, such as difficulty in obtaining a clear clinical history and diagnostic doubt on the part of the physician, given the variety of symptoms that overlap with other pediatric medical conditions at the time of diagnosis[5].

Regarding the out-of-hospital delay, the main cause that in a normal situation would condition the delay in the consultation of children with AA is the late consultation by the caregivers, directly related to some social determinants of health, such as rurality and the greater geographical distance to the healthcare center[6], previous medication with painkillers, and antibiotics[7], and low socioeconomic status[8].

The SARS-Cov-2 pandemic, which emerged in early 2020, presented a major challenge to the population worldwide. The emergence of a devastating, unknown, and threatening disease forced a reorganization of cities and their health systems. In Chile, confinement and multiple measures were initiated to minimize contagion: state of emergency, mandatory use of masks, and mobility restrictions, to keep the population isolated, reaching a peak of 6,500 cases per day in June, 2020[9].

The excessive healthcare demand caused by the disease led to the prioritization of resources for COVID-19-positive patients[10], resulting in resource depletion and the need to create new management protocols. This initiated the use of the pre-hospital COVID PCR test for detection, and surgical activity was adapted with new isolation methods in the operating room, as well as the suspension of scheduled surgeries, to prioritize pandemic management[11].

Although the severity of coronavirus disease is lower in children, with only 1-5% of cases reported as severe versus 10-20% in adults[12], all these measures significantly affected the availability of resources and accessibility of medical care, delaying surgical procedures. If we also consider the intention of the population to stay away from the hospital environment to avoid infection[13], it is necessary to ask what the clinical impact of this delay in medical care is and how it would affect confinement during the pandemic.

The delay in care could have been a determining factor in the incidence of complications in AA, with an increase in morbidity and mortality during this period[14]. In the case of AA, both in children and adults, the pandemic had an impact on the quantity, diagnosis, and management strategies, as well as on the outcomes of patients operated on due to this pathology[15].

It has recently been reported that the quantity of AA cases admitted to the emergency department decreased during the pandemic. Rosenthal et al reported a significant reduction in admissions due to AA in 77% (n = 146) of the hospitals studied during the pandemic[15]. In Germany, a significant decrease in the number of appendectomies during confinement was also demonstrated[16]. Regarding complications, in Hungary, a study suggested that there is an increase in the rate of complicated appendicitis in COVID-19 patients, however, this increase would be attributed to an international trend and would not be correlated with the pandemic or the virus[17]. While other studies have failed to find a significant increase in the complicated appendicitis rate during the pandemic[1], in the U.S., a study that considered the time of maximum confinement observed a significant increase in the rate of complicated appendicitis[18]. Most conflicting literature and the discrepancy of the current results do not have a common denominator regarding the impact of the pandemic on the diagnosis of AA and the incidence of its complications.

The objective of this work is to study the population with AA in a pediatric hospital during the pandemic period, hypothesizing that there would be an

increase in the rate of children with complicated AA, due to the delay in consultation during this period.

Patients and Method

Retrospective cohort study of pediatric patients with AA. We compared all pediatric patients (under 15 years of age) with acute abdomen of appendicular origin, including diagnoses such as AA, peritonitis, and appendicular mass, who were admitted to the emergency department of the *Hospital Roberto del Río* during the pre-pandemic period between March and December 2018, and March and December 2020, during the pandemic.

The analysis of 2019 is discarded as a control group, to eliminate the influence of mobility restrictions on the Chilean population after the social uprising occurred that year, determining that 2018 was a more representative year.

Data were collected from the electronic clinical records and were handled anonymously. The following demographic data were recorded: sex, age, distance to the healthcare center, and nationality. Symptoms such as fever, vomiting, and abdominal pain, as well as time of progression before consultation, number of consultations before diagnosis, acute phase reactants such as C-reactive protein, leukocyte count, COVID PCR test result, postoperative diagnosis, surgical approach, length of hospital stay, length of antibiotic treatment, number of admissions to the critical patient unit (CPU), postoperative complications such as intra-abdominal abscess, postoperative wound infection, reoperation, and exacerbations in the case of appendiceal mass managed medically.

This study was approved by the SSMN ethics committee.

Data analysis

The terminology for grouping patients according to their surgical protocol and clinical history was divided into:

1. Uncomplicated Acute Appendicitis (UAA): it included patients with cecal appendix without macroscopic perforation and no findings of peritonitis.
2. Complicated Acute Appendicitis (CAA): it included patients with cecal appendix with macroscopic perforation, presence of pus or fecal material in the abdominal cavity, abscess, and appendicular mass. Patients with appendicular mass who received only medical management were also included in this denomination.

The data analysis was performed comparing both periods; the total group of patients with AA was analyzed, secondly, the group of CAA patients, and finally, from the latter, only the patients with appendicular mass were analyzed separately.

Patients were grouped into 2 categories according to distance to the healthcare center:

a) Neighboring communes: these are the communes that border the commune of the healthcare center, such as Independencia, Recoleta, Santiago, Conchalí, Quinta Normal, and Renca.
b) Distant communes: non-neighboring communes such as Huechuraba, Quilicura, Lampa, Batuco, and Colina, among others.

Statistical Analysis

A descriptive analysis of the study population was performed. Data were presented as mean and standard deviation for parametric variables and as median and interquartile range for nonparametric ones. Nominal or ordinal variables were presented as absolute frequency and percentage. The Shapiro-Wilk test was used to test the normality of the data. The t-test or Mann-Whitney U test was used for numerical variables, according to the normality of the data, and chi-square for categorical variables. A $p<0.05$ value was considered statistically significant. The GraphPad Prism v 9.3 statistical software was used for analysis.

Results

671 patients were included who were admitted due to suspicion of AA in both periods. 42 cases were excluded that did not correspond to AA, where a healthy appendix was identified and were categorized as negative laparoscopy or laparotomy or attributed to another underlying pathology. These cases involved 22 patients in 2018 and 20 patients in 2020.

Therefore, 629 patients were included from both periods, who were divided into patients diagnosed with UAA and CAA. The CAA group included patients with peritonitis and appendicular mass, both those who were recognized during surgery and those who were diagnosed clinically and received medical management (figure 1).

In the pre-pandemic period, 328 patients were admitted due to AA, and 301 patients in the pandemic period. Sociodemographic aspects such as age, nationality of parents, and distance to the healthcare center were not significantly different in both periods (table 1).

In the clinical history, the time to consultation of all patients with AA in the pandemic period was longer than in the pre-pandemic period (41.2 hours vs 35.5 hours; $p < 0.05$). The surgical approach in the pandemic was predominantly laparoscopic, with 62.4%

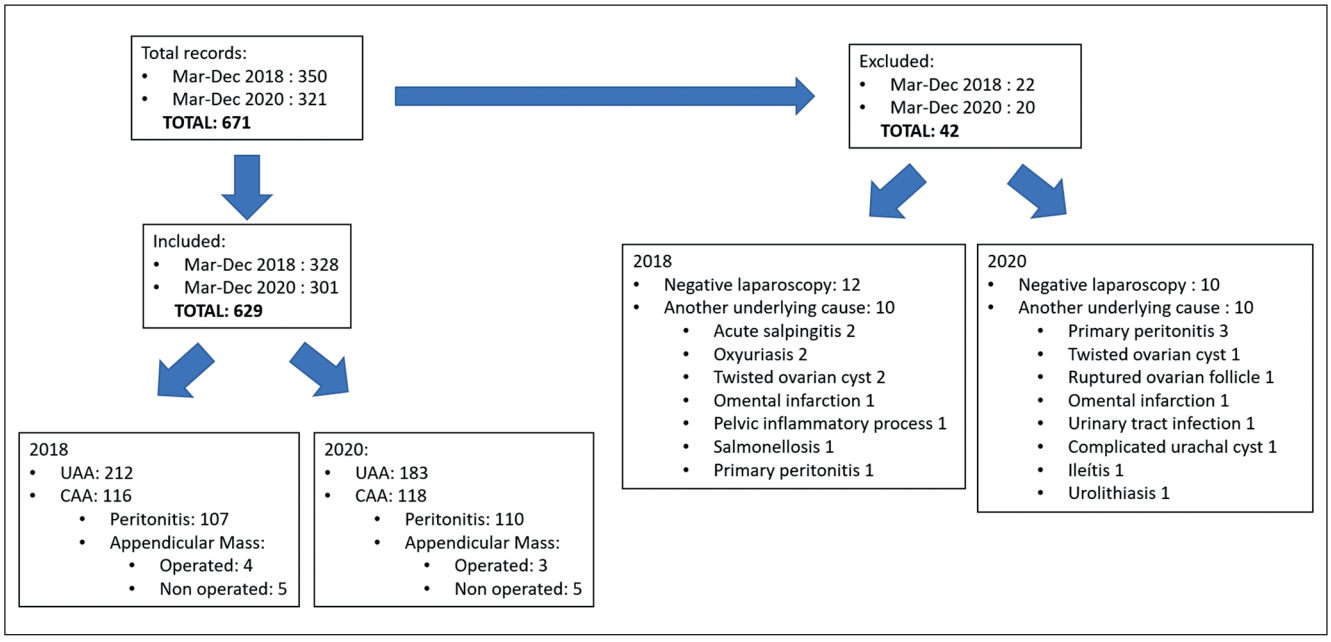

Figure 1. Diagram of patients admitted for suspected surgical acute abdomen of appendiceal origin in both periods. UAA: Uncomplicated Acute Appendicitis CAA: Complicated Acute Appendicitis.

Table 1. Sociodemographic history of pediatric patients with acute appendiceal pathology

	Pre-pandemic (n = 328)	Pandemic (n = 301)	p
Age (mean ± SD) years	9.9 ± 2.9	10.2 ± 2.9	0.349
Gender (n,%)			
Man	225 (68.6%)	198 (65.8%)	0.496
Women	103 (31.4%)	103 (34.2%)	
Parents' nationality (n,%)			
Chilean	288 (87.8%)	257 (85.4%)	0.412
Foreign	40 (12.2%)	44 (14.6%)	
Distance to the center of attention** (n,%)			
*Neighbors	123 (37.5%)	114 (37.9%)	
** Distant	205 (62.5%)	187 (62.1%)	0.935

*Neighboring communes: these are the communes that border the commune of the healthcare center, such as Independencia, Recoleta, Santiago, Conchalí, Quinta Normal, and Renca. **Distant communes: non-neighboring communes such as Huechuraba, Quilicura, Lampa, Batuco, and Colina, among others.

vs 39.9% in the pre-pandemic period ($p < 0.001$). The number of patients admitted to CPU was higher the in pandemic than in the pre-pandemic period (3.9% vs 0.6%; $p < 0.05$) (table 2). There were only two patients with positive COVID-19 PCR tests.

We evaluated whether distance to the healthcare center was related to time of progression, finding no significant differences between distance and time of progression in any period; pre-pandemic ($p = 0.645$), and pandemic ($p = 0.826$), with a median of 24 hours observed for each distance and period.

Other clinical data were analyzed: symptoms such as pain, vomiting, and fever; laboratory tests such as leukocyte count, C-reactive protein, length of hospital stay, days of antibiotic treatment, and postoperative complications where no significant differences were observed (table 2).

Regarding the group of CAA, out of 328 patients with AA in the pre-pandemic period, 116 patients were analyzed which corresponds to 35% of the total, and in the pandemic period, 118 out of 301 patients which corresponds to 39%. The mean time from symptom

Table 2. Clinical history of pediatric patients with acute appendiceal pathology

	Pre-pandemic (n = 328)	Pandemic (n = 301)	p
Time to consultation (hours)	35.5 (24; 5 – 240)	41.2 (24; 3 – 240)	< 0.05*
Symptoms (n, %)			
Pain	328 (100%)	301 (100%)	0.999
Vomiting	263 (80.2%)	246 (81.7%)	0.685
Fever	174 (53.0%)	150 (49.8%)	0.426
Leukocyte count	16.477 ±5.269	17.159 ±5.210	0.098
Type of surgery (n, %)			
Open	192 (58.5%)	108 (35.9%)	< 0.001*
Laparoscopic	131 (39.9%)	188 (62.4%)	
Non operated	5 (1.5%)	5 (1.7%)	
Length of hospital stay	2 (1 – 28)	3 (1 – 40)	0.903
Antibiotic days	1 (1 – 20)	3 (1 – 25)	0.069
CPU (n, %)	2 (0.6%)	12 (3.9%)	< 0.05*
Complications (n, %)	14 (4.3%)	17 (5.6%)	0.464

Critical patient unit (CPU), length of hospital stay and days of antibiotic treatment were expressed as median and range.

Table 3. Complicated Acute Appendicitis (CAA)

	Pre-pandemic (n = 116)	Pandemic (n = 118)	P
Commune distance			
Neighbors	46 (39.7%)	43 (36.4%)	0.687
Distant (n, %)	70 (60.3%)	75 (63.6%)	
Parents' nationality (n,%)			
Chilean	99 (85.3%)	101 (85.6%)	0.999
Foreign	17 (14.7%)	17 (14.4%)	
Time to consultation (hours)	24 (6 – 240)	48 (8 – 240)	< 0.01*
Prior consultations	1 (1 – 4)	1 (1 – 3)	0.316
Length of hospital stay	5 (2 – 28)	5 (1 – 40)	0.903
Antibiotic days	7 (1 – 20)	7 (1 – 25)	0.989
CPU (n, %)	2 (1.7%)	9 (7.6%)	0.059
Complications (n, %)	13 (11.2%)	13 (11.0%)	0.999

Critical patient unit (CPU), length of hospital stay, prior consultation and days of antibiotic treatment were expressed as median and range.

onset to consultation in the pandemic period was 59.5 vs 45.4 hours in the pre-pandemic period, showing a statistically significant increase ($p < 0.01$). In variables such as distance and nationality, no differences were observed between the two periods. There were also no significant differences in the number of previous consultations, days of hospitalization, and treatment, as well as the need for CPU and complications (table 3).

In the appendiceal mass group, operated and non-operated patients were included. 9 patients were registered in 2018 and 8 in 2020. The time of progression before consultation of both groups was analyzed, with no significant differences. No differences were also observed in the number of previous consultations. However, with respect to the days of hospitalization in the pre-pandemic period, these were on average 7.8 days which increased to 11.6 days during the pandemic ($p < 0.05$). Another finding in this group was the number of days of antibiotic treatment, where an increase was observed in the pandemic period with 17 days on average vs 11.1 days in the pre-pandemic period (table 4).

Table 4. Appendicular mass

	Pre-pandemic (n = 9)	Pandemic (n = 8)	p
Commune distance (n, %)			
Neighbors	5 (55.6%)	7 (87.5%)	0.294
Distant	4 (44.4%)	1 (12.5%)	
Parents' nationality (n, %)			
Chilean	7 (77.8%)	6 (75%)	0.999
Foreign	2 (22.2%)	2 (25%)	
Time to consultation (hours)	144 (24 – 240)	168 (96 – 240)	0.229
Prior consultations	2 (1 – 3)	1.5 (1 – 2)	0.198
Length of hospital stay	7 (5 – 14)	10 (7 – 21)	< 0.05*
Antibiotic days	10 (7 – 14)	17.5 (10 – 21)	< 0.05*
CPU (no.%)	0 (0%)	1 (12.5%)	0.471

Critical patient unit (CPU), length of hospital stay, prior consultation and days of antibiotic treatment were expressed as median and range.

Discussion

This study allows a thorough analysis of the relationship between confinement and AA. The rate of patients with AA in both periods was similar, finding no decrease in consultations due to this pathology in contrast to what is reported in the literature[15,16].

The first relevant finding of our study was the longer time elapsed from the onset of symptoms to the diagnosis of the disease observed during the pandemic. This finding correlates with that found by other authors, such as Velayos et al[14] in Spain, and implies a significant delay in consultation, with an average of 14 hours more progression time during the pandemic compared with a normal year.

In the analysis of the influence of the pandemic on the disease progression time, our study focused on the out-of-hospital delay rather than the in-hospital one. This differs from the study by Bonilla[1], where a longer progression time before surgery was found, attributing this delay to waiting for the COVID-19 PCR test result before proceeding with the surgery. In our experience, the COVID PCR test result was not a requirement for admission of the patient to the operating room since the protocols elaborated during the pandemic period at the national level were directed to assume the positivity of the test and the use of personal protection elements in all patients with a pending result, so this is not an incident factor in the delay observed in our results.

When analyzing the distance to the healthcare center in relation to the time of progression, in the pre-pandemic and pandemic periods, there were no significant differences between both groups, observing that this delay was not influenced by distance. In addition, the number of previous consultations was similar in both groups, so it could not be asserted that this delay was related to a late diagnosis secondary to diagnostic doubt.

Therefore, considering that the delay cannot be attributed to distance, nor diagnostic doubt, we may assume that this delay is largely secondary to the effects of the pandemic and confinement. The global threat, mobility restrictions, and the intention to stay away from healthcare systems to prevent contracting the virus represent factors that invariably affect the time before consultation.

Currently, there is great controversy regarding the clinical repercussions of this delay in consultation. Although an increase in mortality has been observed in other diseases such as sepsis or malignant processes[19], in this study, we did not observe any patient deaths. However, a greater number of patients were admitted to the CPU during the pandemic period. These patients met the criteria for admission to the CPU established in our internal protocol[20] such as septic shock, severe metabolic and hydroelectrolytic imbalance with requirement of continuous monitoring, as well as immediate post-surgical care with requirement of strict surveillance. This finding associated with the delay in consultation makes it likely that the septic and hydroelectrolytic condition of patients requiring more aggressive management upon admission contributed to the greater severity of the cases. It highlights a group of children who were admitted in worse clinical conditions, evidencing greater severity in the presentation of AA during the pandemic due to this delay.

Regarding the higher number of laparoscopic appendectomies performed during the pandemic com-

pared with the previous period, at the beginning, the lack of clinical experience in dealing with the disease led to multiple doubts regarding the risk of performing procedures that generated aerosol release. The literature describes an important change in surgical management during the pandemic, where the conversion from laparoscopic surgery to open surgery prevails[21]. In our experience, this was the case at the beginning, however, the fact that we faced the pandemic later than Asia and Europe, allowed us to be warned in time as to the low probability of aerosol dispersion with the use of minimally invasive surgery[22], keeping the active use of this surgical technique. But this increase could also be attributed to the natural progression of the experience of the center and the surgical team in minimally invasive surgery, which, knowing its multiple benefits, positions it as the technique of choice in children with appendicitis[23] and to the greater availability of surgical instruments over the years in our center, which has favored its accessibility.

Although our hypothesis was to find an increase in the rate of CAA during the pandemic, as has been seen in other studies[18,24,25], this was not observed in our results. When analyzing the group of CAA, we observed an increase in the time of progression before consultation, but no other significant findings, neither in the rate of complications nor in the number of admissions to the CPU.

We found it interesting to analyze the appendicular mass group separately, despite the small number of patients, given the direct relationship between this pathology and the longer progression time of symptoms and its well-known association with higher morbidity[26].

The abdominal mass composed by the agglutination of intestinal loops and/or omentum in relation to the local inflammatory process of the perforated cecal appendix that composes the appendiceal mass can be found in an organized phase depending on the days of progression of the picture[27]. The literature describes that the process would start after 72 hours and that it would be more common in children under 5 years of age[28].

If we consider the delay in consultation during the pandemic period, it is presumed that there would be a greater number of these cases. In this study, we observed around 2.5% rate in both periods, which would be expected according to the literature between 2-10% of the total number of appendicitis[26].

In this group, a prolonged hospital stay and antibiotic treatment were observed during the pandemic. In 2017, a systematic review compared the outcomes of emergency versus deferred appendectomy in cases of appendicular mass in the general population[26], observing an average of 6.7 days of hospitalization. Our results showed a much higher number in the pandemic, with 11.6 days on average. We believe that the more extended in-hospital management could be attributed to the apprehension on the part of the medical team, who, knowing the situation in the pandemic, the mobility restrictions, and presuming the mobility delay, assumed a more paternalistic role in the treatment, trying to control the infectious process during the hospital stay, knowing that the difficulties in accessing subsequent check-ups and emergency visits for recurrent symptoms could condition worse results.

This same argument would explain the longer antibiotic treatment time, which increased to 17 days in the pandemic, in contrast to that reported by St. Peter in his prospective randomized study conducted in Kansas City, where he describes that the average duration of antibiotic treatment was 6 to 7 days[29].

This study has some limitations. Since it is a single-center study, the results may be subject to bias due to the characteristics of the care provided at our center. Being a retrospective study, the clinical records are already closed. However, data collection was carried out by a single investigator, thus providing greater homogeneity to the registry. The electronic clinical records available in our center allow a minimal loss of data, which we consider was not significant.

This study concludes that during the pandemic there was a delay in consultation and a greater need for intensive management in pediatric patients with AA in our sphere, which denotes greater severity of the cases due to the delay caused by the confinement. There was a longer hospital stay and an extension of antibiotic treatment in cases of appendicular mass. The laparoscopic technique was the approach of choice during the pandemic. The findings of this study allow us to know the behavior of the disease in times of health emergency and to direct future efforts in the education and implementation of clinical guidelines for the management of this pathology in times of pandemic.

Ethical Responsibilities

Human Beings and animals protection: Disclosure the authors state that the procedures were followed according to the Declaration of Helsinki and the World Medical Association regarding human experimentation developed for the medical community.

Data confidentiality: The authors state that they have followed the protocols of their Center and Local regulations on the publication of patient data.

Rights to privacy and informed consent: The authors have obtained the informed consent of the patients

and/or subjects referred to in the article. This document is in the possession of the correspondence author.

Conflicts of Interest

Authors declare no conflict of interest regarding the present study.

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