Efficient Organization of The Diagnostic Process In The Emergency Department of Patients With Acute Appendicitis During The COVID-19 Pandemic

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Research Article

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Abstract

Background. The COVID-19 pandemic has forced significant changes in the functioning of health care systems worldwide. The availability of health resources and patient readiness to present to the hospital have been reduced. COVID-19-related safety procedures might have potentially disturbed diagnostic and therapeutic processes in the emergency department (ED), leading to noticeable delays in service with a possible negative impact on the final therapeutic outcome. The aim of this study was to assess whether changes in the health care system and designed modes of functioning of the ED during the pandemic had negative consequences on the diagnostic process and final effect of treatment of subjects with acute appendicitis.

Methods. Due to the pandemic, certain changes in the functioning of emergency departments were implemented to ensure the safety of patients and the staff. We performed a retrospective analysis of the charts of patients diagnosed with acute appendicitis in the ED before (from 10.03.2019 to 31.12.2019) and during the pandemic (from 10.03.2020 to 31.12.2020). We compared the period from symptom onset to admission to the hospital, demographic and clinical features (including appendicitis severity), time intervals between crucial events in the diagnostic and therapeutic process and final results of therapy.

Results. We included 133 patients (69 in the prepandemic period and 64 in the pandemic period). There were no significant differences in terms of demographic characteristics and comorbidities. During the pandemic, patients presented to the hospital later than before the pandemic, although the difference was not statistically significant (2.6 vs. 1.9 days from symptom onset, p=0.108). The severity of acute appendicitis was significantly higher during the pandemic according to the clinical scales used. For patients who underwent surgery, the time from admission to the beginning of the operation did not differ significantly before versus during the pandemic. We did not find significant differences in length of stay, rates of complications, reoperations or rehospitalizations between the prepandemic and pandemic periods.

Conclusions. Our data show that COVID-19-related changes in the functioning of the ED did not lead to delays in the diagnostic process or to worsening of the therapeutic effect in patients with acute appendicitis.

1. Background

Since the beginning of 2020, the world has struggled with the COVID-19 pandemic caused by the SARS-COV-2 virus. To date, according to WHO reports, 195 886 929 subjects have been infected globally, with 4 189 148 deaths. The pandemic has imposed a severe burden on the global health care system, with special emphasis on emergency medicine systems. Emergency departments (EDs) are responsible both for accurately diagnosing and initiating therapy for COVID-19 [[2] [3]] and for providing a stable service for patients with other disorders. [[4] [5]] Those tasks should be performed while assuring both the patients'

and the staff's epidemiological safety. Ideally, despite the presence of the pandemic, the quality of service dedicated to other medical problems in the ED should remain unchanged.

Acute appendicitis (AA) can be considered a model acute surgical disorder that is diagnosed and qualified for further therapy in the ED. Its prevalence ranges from 89/100 000 to 233/100 000 inhabitants per year [[6] [7] [8] [9]]. According to previously published studies, the pandemic led to significant perturbations in the diagnostic and therapeutic process of AA as a consequence of delays in hospital attendance, in-hospital epidemiological procedures and surgeon transfer to dedicated COVID-19 wards. [[10] [11] [12]] It is also crucial to note that COVID-19 can present with gastrointestinal symptoms as well, posing a challenge to accurate patient diagnosis. [[13]] These perturbations have the potential to worsen the therapeutic results. [[14]]

The aim of this study was to verify the following 3 hypotheses in the context of a single emergency department in Poland:

1. Delays in AA patients' hospital attendance with consequent more severe clinical presentation of AA were observed during the COVID-19 pandemic.

2. In-hospital procedures related to epidemiological safety led to delays in diagnostic and therapeutic procedures in patients with AA.

3. The final results of AA therapy were worse during the COVID-19 pandemic due to the above mentioned delays.

2. Materials And Methods

2.1. Settings of the study

The study was performed in an emergency department located in a city of 582 205 inhabitants in a hospital with 1100 beds, admitting 30 000 patients per year. Each day, there were 5 doctors (with one specialist in emergency medicine), 9 nurses and 1 paramedic on duty. It is one of the 3 emergency departments located in the city. During the pandemic, there were 2 other hospitals in the city dedicated exclusively to patients with COVID-19. One of those hospitals was designated for noncomplicated cases of COVID-19, and the other was designated for patients in need of specialist care in addition to COVID-19 therapy.

The department consists of several spaces: apart from the doctors' offices, there is a waiting area where patients await being admitted, an observation room where they receive fluid therapy and medications and are monitored by nurses, a shock room where the most acute patients are being examined and handled and the ICU where they are later admitted if still needing intensive care.

2.2. COVID-19 specific changes in ED functioning

A pandemic state requires implementation of some nationwide changes in functioning of the health care system. Tele consultancies became common as a response to advice on maintaining social distance, meaning avoiding crowded places such as EDs or hospitals. Unfortunately, making an appointment with a general practitioner or a specialist started to become difficult. Hospitals dedicated to COVID-19 patients exclusively were created, as well as surgical departments in other hospitals.

To avoid spreading the virus among patients and medical staff, the hospital instituted obligatory PCR tests for all subjects admitted to hospital departments. Three different levels of urgency were created for PCR tests: (1) standard test with 6-7 hours waiting time, (2) urgent test with 3 hours waiting time and (3) rapid test, taking 1 hour to receive a result. Rapid PCR tests were intended for those suspected of needing urgent surgery, e.g., presenting with AA symptoms or other acute surgical disorders.

Creating a place for subjects waiting for their PCR test results was an additional issue. Apart from regular offices for admitting patients, 3 isolation rooms were created for subjects with clinical suspicion of COVID-19. These rooms were dedicated to performing initial procedures (e.g., physical examination, blood and swab taking) in suspected patients. Apart from that, a transitional observational 14-bed ward was created within the ED. Patients tested for COVID-19 were isolated in that ward while waiting for the results of PCR tests, receiving the required treatment or undergoing diagnostic procedures. Whether or not in the ED, a special COVID ward was created within the hospital for subjects with COVID-19 requiring hospitalization.

2.3 Standard and pandemic diagnostic ED procedure for patients with suspicion of AA.

Routinely (before the pandemic), a patient with suspicion of AA underwent the following pathway: triage, history taking, physical examination, laboratory tests (CPR, blood cell count, glucose, coagulogram, creatinine, electrolytes, blood group, general urine examination), and imaging (ultrasound examination of the abdomen and contrast-enhanced tomography in case of clinico-radiologial uncertainty). A surgical assessment was performed after completing the additional tests, with a final decision on admission to a surgical ward and further operation.

During the pandemic, the diagnostic method of AA-suspected patients changed. As early as triage, patients were asked about contacts with people who were quarantined due to suspicion of or diagnosis with COVID-19. Nurses or paramedics checked whether patients presented with alarming symptoms or parameters, e.g., cough, high fever, desaturation or dyspnoea. In cases of COVID-19 suspicion (one of cough, dyspnoea, or fever), the patient was led to an isolation room in the ED to undergo the required procedures (physical examination, blood sample collection, swab taking, initial pharmacotherapy). During the doctor’s examination, PCR tests were performed for patients suspected of needing acute surgery. Ultrasound examination was eliminated from the diagnostic workup to reduce the risk of contamination of the radiological staff and was entirely replaced by a contrast-enhanced CT scan of the abdomen. After the initial diagnostic procedures, patients were placed in the transitional ward for the time needed to receive the results of the tests (including the COVID-19 PCR test) and for surgical consultancy.

Afterwards, determined by the CT scan and PCR test results, the patient was either treated with conservative treatment, transported to the operating theatre or transferred to the surgical ward in one of the COVID-19 hospitals.

2.3. Study design

The study was based upon a retrospective analysis of anonymized data of patients diagnosed in the ED with AA. Data on patient demographic features, clinical condition, course of diagnostic and therapeutic process, and results of therapy were collected. Data from 10.03.2019 to 31.12.2019 and from 10.03.2020 to 31.12.2020 were collected.

Several demographic data were collected, including age, sex and comorbidities.

The clinical condition of the patients was assessed by clinical scales and the number of days from the appearance of symptoms until hospital attendance. The following scales were used to assess the severity of AA:

- The **Alvarado score**, also known by the acronym MANTRELS, is a scale based on symptoms, signs and diagnostic tests for patients presenting with suspected acute appendicitis. MANTRELS stands for migration of pain (1 pt), anorexia (1 pt), nausea (1 pt), tenderness in right lower quadrant (2 pts), rebound pain (1 pt), elevated temperature (1 pt), leukocytosis (2 pts) and shift of white blood cell count to the left (1 pt). An Alvarado score of 1-4 indicates an approximately 30% probability of AA and suggests discharging a patient, and a score of 5-6 indicates a 66% probability of AA and a recommendation of admission/observation. Patients whose score is 7 or higher should undergo surgery, as the probability of AA is approximately 93%. [15]
- **The appendicitis severity index** (APSI) is a scale based on radiological findings used to predict complicated appendicitis (APSI ≥ 4). Radiological parameters assessed by APSI include appendix diameter and wall thickness, periappendiceal fat stranding and fluid, intraluminal and extraluminal air, thinning of appendiceal wall, caecal wall thickening, appendicolith and abscess formation. [16]
- **The appendicitis disease severity score** (DSS) puts patients with AA in the following order: grade 1, inflamed; grade 2, gangrenous; grade 3, perforated with localized free fluid; grade 4, perforated with a regional abscess; and grade 5, perforated with diffuse peritonitis. There is a stepwise risk increase in adverse outcomes with higher DSS grades. [17]
- **The quick sequential organ failure assessment** (qSOFA) score predicts the risk of sepsis and therefore death in emergency patients. The qSOFA score is positive in the presence of two of the three following elements: systolic blood pressure ≤ 100 mm Hg, respiratory rate ≥ 22 breaths/min, and Glasgow coma scale score ≤ 14.[18]
- **Systemic inflammatory response syndrome** (SIRS) criteria include abnormal body temperature (>38°C or <36°C), increased heart rate (>90 bpm), increased respiratory rate (>20/min) or decreased $PaCO_2$ (<32 mmHg) and abnormal white cell count (>120000/μL or <40000/μL). Mortality increases linearly with each additional SIRS criterion met. [19]

To describe the diagnostic process, the following time points were noted: admission to the ED, first diagnostic test, imaging test, result of imaging test, placement and performance of the surgeon's consult, patient transfer to the surgical ward and time of surgery. Authors measured the following time intervals:

- from admission to first the diagnostic test
- from placing to obtaining the results of the imaging test
- from commission to performing of surgical consult
- from admission to surgeon's decision
- from admission to transfer to the surgical ward
- from admission to surgery

Therapeutic success was calculated based on length of hospital stay, rate of reoperations and rehospitalizations, deaths and ICU admissions.

The study design was approved by the local Ethical Committee of the Medical University of Gdansk (approval NKBBN/140/2021).

3.4. Statistical analysis

Data are presented as the mean values with standard deviation. Continuous data were compared with T test and discrete data were compared with chi-squared tests.

3. Results

There were 69 patients in 2019 and 64 in 2020. Their demographic data (sex, age, and comorbidities) are presented in Table 1. There were no significant differences in demographic variables between patients treated in 2019 and 2020.

TABLE 1. Demographic features of AA patients in 2019 and 2020

	2019	2020	P value
Age	40.62±17.16	44.41±15.74	0.189
Sex			
Female	33	24	
Male	36	40	0.29
Comorbidities			
Arterial hypertension	12	9	0.64
Coronary artery disease	2	1	NS
Diabetes mellitus	2	2	NS
Renal failure	0	1	NS
Atrial fibrillation	0	2	NS
Inflammatory bowel disease	2	0	NS
COPD	0	1	NS
Arthritis	2	3	NS
Previous abdominal operation	5	4	NS

COPD - Chronic obstructive pulmonary disease, NS - nonsignificant

Although the time from the beginning of symptoms until hospital attendance was longer in 2020 than in 2019 (2,59 days vs. 1,94 days), the difference was not significant (p= 0,108). Nevertheless, the clinical presentation of subjects in 2020 was significantly more severe. Patients' scores on all applied scales (Alvarado, DSS, APSI, SIRS) were higher in 2020, although disease severity was not noticed in laboratory tests (CRP and white blood cell count). Data are presented in Table 2.

TABLE 2. Clinicometric and laboratory results of AA patients in 2019 and 2020.

	2019	2020	P value
Duration of symptoms (days)	1.94±1.41	2.59±3.01	0.108
Results of clinical scales (mean ± Standard deviation)			
Alvarado	5.16±2.06	5.80±1.54	**0.046**
APSI (appendicitis severity index)	2.02±1.67	2.73±1.82	**0,019**
SIRS	1.07±0.81	1.38±0.75	**0.027**
DSS (number of patients in each category)			
1	48	32	0.015
2	5	5	1.000
3	3	1	0.620
4	0	5	0.021
5	1	7	0.025
Laboratory parameters of inflammation			
CRP	78.61±83.39	91.00±93.59	0.421
WBC	12.95±4.41	14.13±4.57	0133

Alvarado – Alvarado score; APSI – appendicitis severity index; SIRS - Systemic inflammatory response syndrome; DSS – disease severity score; CRP – C-reactive protein; WBC – white blood cells count.

The mean intervals measured during the diagnostic and therapeutic process were longer in 2020, but the difference was not clinically significant. The intervals (hh:mins) are presented in Table 3.

TABLE 3. Duration of selected intervals in the diagnostic and therapeutic process of AA subjects in 2019 and 2020.

	T1 – from admission until CT scan ordering		T2 – from admission until clinical decision		T3 – from admission until surgery	
	2019	2020	2019	2020	2019	2020
Mean	1:57:13	2:10:46	7:48:59	9:13:20	12:02:15	13:10:01
±SD (hours)	±1:58:54	±1:58:00	±5:47:19	±5:06:02	±8:25:32	±7:02:00
P value	0.511		0.04		0.450	

The results of therapy measured with length of stay, reoperations, number of deaths, and number of ICU admissions did not differ significantly between the analysed periods, as shown in Table 4. The number of

rehospitalizations was lower in 2020.

TABLE 4. Measured effects of therapy in 2019 and 2020 years.

	2019	2020	P value
Deaths	0	0	1
Reoperations	0	0	1
Rehospitalizations	11	3	0.047
ICU admissions	0	0	1
Length of stay (days)	2.44±1.55	3.58±4.97	0.071

5. Discussion

Our data shows the following:

- A nonsignificant increase in the period from the beginning of symptoms of AA to hospital admittance was observed.

-The delay in hospital admittance was correlated with a more severe clinical AA presentation in 2020.

- Changes in ED functioning did not lead to a significant delay in therapeutic and diagnostic processes in patients with AA

- The final results of therapy during the pandemic were comparable with the results in 2019.

According to some papers [[20] [21] [22]], during the pandemic, patients with acute and serious illnesses, such as AA, presented to hospitals later. This is explained by the fear of becoming infected, as hospitals are seen as the epicentres of the pandemic, and by obeying the recommendations of self-isolation and staying at home. Problems with access to health care system resources (e.g., GP consultancies or outpatient surgical consultancies) also cannot be underestimated [[23] [24] [25]]. This was partially confirmed in our study, as the time from first symptoms until hospital attendance was not significantly longer during the pandemic. It must be noted that in Poland, most outpatient services were at least partially locked down, with severely reduced access to medical assistance from emergency departments.

Some authors found that during the pandemic, patients with AA arrive at the hospital in more severe conditions. [[26] [27]] We observed a similar phenomenon, with higher results on clinical scales of AA during the pandemic. This was explained in other papers by delays in hospital admittance and attempts at self-medication during mild stages of AA. [[28] [29] [11]]

Although certain additional procedures were implemented in our ED, they did not lead to significant elongation of diagnostic and therapeutic processes in patients with AA or to a worsening of the therapeutic effects. This is in concordance with the studies of Zhou Y and Cen LS, Turanli S and Kiziltan G, and Willms et al. [[30] [31] [32]] In some papers, this process was less effective than before the pandemic. [[33]] Analysing the data presented in this paper, it is not entirely clear what led to the delay, as the authors cited the change in “in-hospital and operation room logistics and intensive care capacities”.

Despite the more severe conditions of our patients, according to the scores on clinical scales, quality measures of therapy were similar in 2019 and 2020. Other authors found that during the pandemic, surgical therapy for AA was related to worse effect and more complications, [[34] [12] [35]] although other authors reached similar conclusions to ours, noting that the pandemic was ultimately not linked with worse surgical effects. [[36] [37]]

STUDY LIMITATIONS

The weakness of our study is the fact that it comes from a single centre., which resulted in a relatively small number of cases. However, it must be noted that performing such a study with a multicentre design would be very difficult, as there has been no unified mode of action across EDs during the pandemic; therefore, each hospital has its own procedures. This would lead to a significant bias. Another weakness is the retrospective nature of our study. It must be noted that due to the dynamics of the pandemic itself and pandemic-related changes in the functioning of health care system planning, prospective protocols would be extremely difficult to implement and would probably fail.

Conclusions

Our data showed that during the pandemic, patients with AA had more severe symptoms, but this did not negatively impact the final results of therapy. Moreover, we showed that measures of epidemiological safety taken in our EDs did not allow any SARS-COV-2-positive patient to be admitted to a noninfectious department, simultaneously preventing significant prolongation of diagnostic and therapeutic processes in patients with AA.

As previously stated, [[38] [34]] it is critical to advise patients to seek urgent medical care if suspecting a health emergency. It is not known how long the pandemic will prevail, so we must minimize the detrimental effects of delaying medical treatment.

List Of Abbreviations

ED: emergency department

WHO: World Health Organisation

AA: acute appendicitis

ICU: intensive care unit

PCR: polymerase chain reaction

CT: computed tomography

APSI: appendicitis severity index

DSS: disease severity score

qSOFA: quick sequential organ failure assessment

SIRS: systemic inflammatory response syndrome

COPD: chronic obstructive pulmonary disease

NS: nonsignificant

CRP: C-reactive protein

WBC: white blood cells

GP: general practitioner

Declarations

Ethics approval and consent to participate

Study design was approved by local Ethical Committee of Medical University of Gdansk, (approval NKBBN/140/2021)

Consent for publication

Not applicable.

Availability of data and materials

There are no additional data available to share with the readers. Data can be shared if requested.

Competing interests

The authors declare that they have no competing interests.

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There was no funding for this research study.

Authors' contributions

NC: conceptualization of the study, data acquisition (lead), preparing draft of the manuscript (lead), preparing final version of the manuscript

TŁ: conceptualization of the study, data acquisition, correction of the manuscript

MS: conceptualization of the study (lead), data curation, statistical analysis (lead), preparation final version of the manuscript.

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Figures

Figure 1

Standard diagnostic procedure for patients with suspicion of acute appendicitis

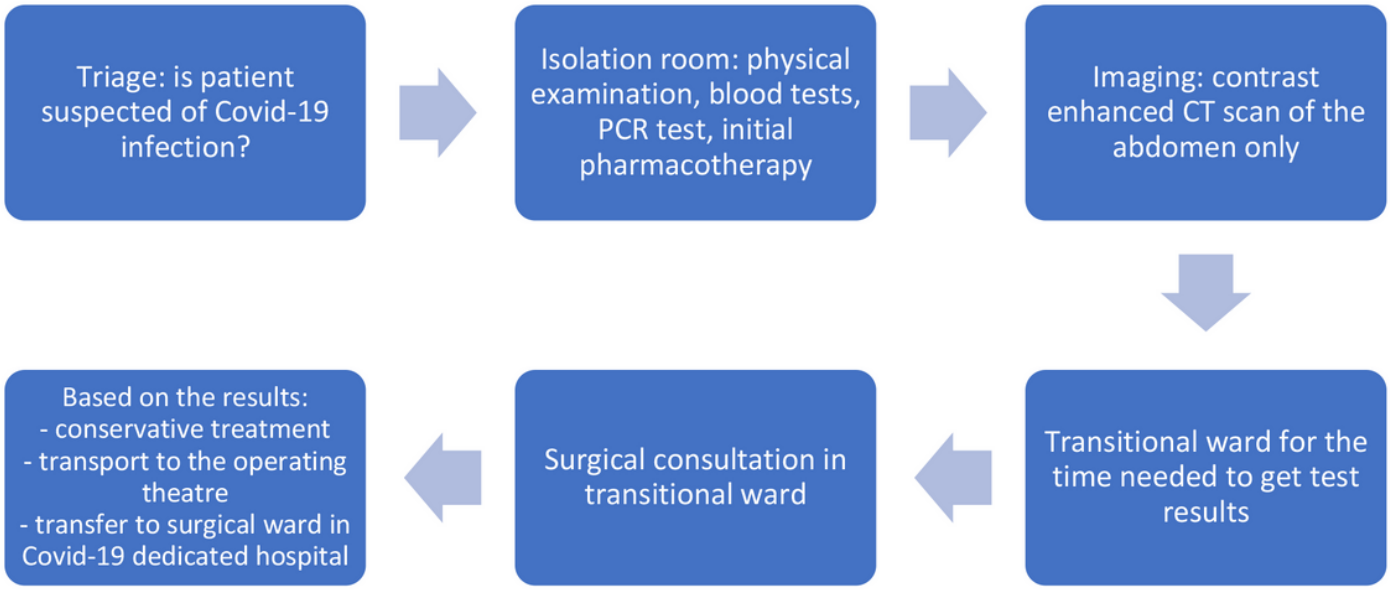

Figure 2

Pandemic diagnostic procedure for patients with suspicion of acute appendicitis