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Rapid triage and transfer system for patients with proven Covid-19 at emergency department

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Abstract
Background: COVID-19 is a viral disease notorious for frequent worldwide outbreaks. It is difficult to control, thereby resulting in overload of the healthcare system. A possible solution to prevent overcrowding is rapid triage of patients, which makes it possible to focus care on the high-risk patients and minimize the impact of crowding on patient prognosis.
Methods: The triage algorithm assessed self-sufficiency, oximetry, systolic blood pressure, and the Glasgow coma scale. Compliance with the triage protocol was defined as fulfillment of all protocol steps, including assignment of the correct level of care. Triage was considered successful if there was no change in the scope of care (*e.g.*, unscheduled hospital admission, transfer to different level of care) or if there was unexpected death within 48 hours.
Results: A total of 929 patients were enrolled in the study. Triage criteria were fulfilled in 825 (88.8%) patients. Within 48 hours, unscheduled hospital admission, transfer to different level of care, or unexpected death occurred in 56 (6.0%), 6 (0.6%), and 5 (0.5%) patients, respectively. The risk of unscheduled hospital admission or transfer to different level of care was significantly increased if triage criteria were not fulfilled [13.1% vs. 76.1%, RR 5.8 (3.8–8.3), $p < 0.001$; 0.5% vs. 5.2%, RR 11.4 (2.3–57.7), $p = 0.036$, respectively].
Conclusion: The proposed algorithm for triage of patients with proven COVID-19 is a simple, fast, and reliable tool for rapid sorting for outpatient treatment, hospitalization on a standard ward, or assignment to an intensive care unit.

Keywords: COVID-19; SARS-CoV-2; Triage

Highlights:
- Clinical triage is a simple way for the assessment of management of COVID-19 patients.
- Triage minimizes length of stay on the emergency department and thus prevents crowding.
- The incidence of adverse events was increased if triage criteria were not met.

Abbreviations:
ICU – intensive care unit; ECMO – extracorporeal membrane oxygenation.

Introduction

SARS-CoV-2 virus is a highly infective pathogen related to COVID-19 disease (Coronaviridae Study Group of the International Committee on Taxonomy of Viruses, 2020). Since its first detection in late 2019, COVID-19 became notorious for frequent worldwide outbreaks which were difficult to control, resulting in the overload of healthcare systems and high death tolls (Sachs et al., 2022).

In the early phase of the pandemic described in the study, most symptomatic patients from all over the world presented with mild symptoms (81–90% of patients), 4–14 % of patients suffered severe symptoms requiring hospitalization on a standard ward, and the symptoms of 1–5% of patients necessitated a stay in the intensive care unit (ICU) (Epide-

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miology Working Group for NCIP Epidemic Response..., 2020; Salzberger et al., 2020; Wiersinga et al., 2020). Most patients with a mild course of COVID-19 avoid visiting the emergency department. However, in the case of a large outbreak this group of patients is often responsible for overwhelming the healthcare system. On the other hand, the group of patients who benefit from intensive care is small and often difficult to recognize early due to the phenomenon called silent ("happy") hypoxia (Simonson et al., 2021). These patients benefit from early intensive treatment in the specialized department rather than a prolonged stay at the emergency department (Alhazzani et al., 2020, 2021; Le Terrier et al., 2022).

A typical bottleneck of the medical system is the transfer capacity of emergency departments that serve as primary contact points for severely diseased patients (Morley et al., 2018, Savioli et al., 2021). Subsequent crowding of emergency departments during COVID-19 outbreaks is harmful for both COVID-positive and COVID-negative patients (Guo et al., 2022; Sartini et al., 2022). A possible solution to prevent crowding and efficiently distribute health care among patients is rapid triage of patients (Kayipmaz and Demircan, 2021), which makes it possible to focus care on the high risk patients and minimize the impact of crowding on patients' prognosis (Burström et al., 2016). However, this approach might be challenging in COVID-19 patients. Firstly, the clinical picture of COVID-19 positive patients is very heterogeneous, encompassing asymptomatic cases, cases with mild respiratory or gastrointestinal symptoms, fewer cases with mild to severe respiratory insufficiency, and occasionally cases with severe complications, *e.g.*, pulmonary embolism, stroke, metabolic disorders, *etc.* (Grant et al., 2020; Wiersinga et al., 2020). Moreover, many patients can deteriorate in days or hours, an eventuality likely to be underscored during initial triage. For these reasons, there is not yet any generally accepted triage scheme for the rapid evaluation of COVID-19 patients.

The scheme introduced in this paper was intended to enable the selection of place of final medical care (intensive care unit; standard ward; outpatient treatment) with minimal, yet sufficient medical examination. It also intended to minimize contact between COVID-19 positive and negative patients. The approval of such proceedings was carried out by the local medical board as a measure to prevent the impending collapse of the local healthcare system.

Materials and methods

Design

This is a retrospective cross-sectional single center analysis of all patients with proven COVID-19 triaged at the emergency department of a tertiary hospital capable of all methods of COVID-19 treatment, including extracorporeal membrane oxygenation (ECMO). Due to lockdown restrictions prohibiting movement between regions, the majority of patients involved in the study were residents of the local district with a population of 163,671.

Data acquisition

Records were analyzed from all patients with proven COVID-19 who underwent pre-specified triage from October 2020 to March 2021. The triage was mandatory for all patients with proven COVID-19 unless they required urgent highly specialized care (*e.g.*, patients with polytrauma, STEMI, stroke *etc.*).

The patient was considered a confirmed case of COVID-19, either if diagnosis was made less than 14 days before the emergency department visit or during the examination. The diagnosis made before an examination at the emergency department had to be established by PCR test or antigen test together with the presence of symptoms of infection (fever, headache, dysosmia), respiratory symptoms (hypoxemia, dyspnea, cough), or gastrointestinal symptoms such as diarrhea. If the COVID-19 infection was not recognized before emergency department visit, PANBIO™ COVID-19 Ag Rapid Test Device (Abbott, USA) (Albert et al., 2021) and COVID-19 Ag FIA nasal for the Standard F200 analyzer (SD Biosensor, Republic of Korea) (Liotti et al., 2021; Perez-Garcia et al., 2021) were used for antigen testing. If the result of antigen test was negative despite clinical suspicion, the patient underwent PCR testing and full clinical examination and was excluded from clinical triage.

In every patient the age, sex, compliance with triage criteria, initial management, length of emergency stay, length of hospitalization, and length of ICU stay were recorded. The time of arrival of the emergency medical service ambulance or the establishment of medical record was considered the beginning of the emergency stay, whichever came first. The time of completion of the medical record or the establishment of the hospitalization record was considered the end of the emergency stay, whichever came first.

Triage scheme

At the time of study initiation, no relevant triage system for COVID patients at emergency department use had been established.

The purpose of the triage was to determine further clinical management using simple clinical and vital signs (Table 1). The triage criteria were based mainly on thorough analysis of patients with proven COVID-19 who tested positive in Hradec Králové Region in spring 2020 (Skala et al., 2021; Vrbacky et al., 2022). The main focus was placed on revealing easily accessible predictors of clinical development.

Self-sufficiency was defined as ability of self-care or access to assisted care that would allow patient to stay at home for at least two following days. This information was reported by the patient or his/her relatives. The blood saturation threshold of

Table 1. Triage scheme

Initial management	Self-sufficiency	Blood saturation	Systolic blood pressure	GCS
Outpatient treatment	yes	>95% without O_2	>90 mmHg	15
Standard ward	no	>95% with O_2 <15 l/min	>90 mmHg	≥13
Intensive care unit	no	<95% with O_2 ≥15 l/min	<90 mmHg	<13

Note: O_2 – oxygenotherapy; GCS – Glasgow Coma Scale.

95% was chosen as sufficient oxygenation, including a safety margin enforced by decision-making based on a single measured value. Threshold of oxygen flow <15 l/min was selected as the level reachable by face mask with a reservoir bag on standard department. The blood threshold of 95 mmHg was chosen as the value usually requiring the use of catecholamines.

Triage was performed by a physician immediately after a diagnosis of COVID-19. The patient was given the highest level of care for which they met at least one indication criterion. If the terminal stage of an incurable disease was known for the patient, the scope of care was determined individually according to the standards of palliative care. Compliance with the triage protocol was defined as fulfilment of all protocol steps including assignments of the correct level of care. With reference to compliance with triage protocol, patients were divided into a "Criteria fulfilled" group or a "Criteria not met" group.

Triage was considered successful if there was no change in the scope of care (*e.g.*, unscheduled hospital admission, transfer to different level of care, hospital discharge), or if there was unexpected death within 48 hours. Unexpected death was defined as death outside of ICU, excluding patients in palliative care. 48 hours scope was selected as the shortest time to initiate reasonable therapy and to observe its effect. It is also the time frame after which COVID-positive patients may deteriorate regardless of initial presentation and treatment (Chen et al., 2020).

Statistical analysis

Categorical variables were described as group counts and relative frequencies (percentages), while continuous variables were described as group means, standard deviations (SDs), and totals (*N*). Tests of statistical hypotheses in contingency tables were performed using the Fisher Exact Test based on a hypergeometric distribution. Statistical significance was set to alpha = 0.05 for all tests. Since most of the continuous variables subject to statistical testing showed significant departures from normality (as indicated by exploratory analysis and Shapiro–Wilk test), a non-parametric Wilcoxon Rank-Sum Test was used to compare the continuous outcomes across different groups defined by either of the treatment arms. In the case of multiple test scenarios (*e.g.*, a battery of tests performed on a batch of variables), a Bonferroni–Holm correction of the nominal level of statistical significance was applied to keep the family-wise Type I error rate alpha at 0.05. The statistical analysis was conducted with the SPSS Statistics 23 (IBM, New York, USA).

Results

A total of 929 patients were enrolled in the study. In 610 (65.6%) patients the diagnosis of COVID-19 was completed before activation of emergency medical service, while in 319 (34.4%) patients the diagnosis was completed in the emergency department; 207 (22.3%) patients were treated as outpatients, while 722 (77.7%) patients were admitted. The average hospital stay was 17.0 days, with an average ICU stay of 6.6 days.

Triage criteria were fulfilled in 825 (88.8%) patients. Baseline demographic and procedural characteristics were well-balanced in both groups. According to medical records of the follow-up visit, the most frequent cause of protocol violation was underestimating the severity of hypoxia [64 (61.3%) mistriaged patients], mainly in oligosymptomatic patients. The second most frequent cause of protocol violation was failure to recognize loss of self-sufficiency [29 (28.6%) mistriaged patients].

If triage criteria were not met, patients were more often sent for outpatient treatment (19.5% vs. 44.2%) and less often for intensive care unit (17.5% vs. 8.7%; $p < 0.0001$). The average length of emergency stay including antigen testing was 12.23 ± 10.87 min. The difference in length of emergency stay was negligible between the study groups (Table 2). It is important to note that the length of emergency stay was much shorter if the diagnosis of COVID-19 was made before arrival (09.60 ± 08.57 min vs. 17.27 ± 12.83 min; $p < 0.0001$), mainly due to the delay in performing the antigen test.

55 (5.9%) of study patients who fulfilled the criteria for ICU treatment were also in the terminal stage of an incurable disease. Palliative care in a standard ward was indicated for these patients. This decision was subsequently reconsidered in two patients. The scope of care was not limited for any patient due to a lack of hospital capacity.

The overall incidence of adverse events was low. Within 48 hours of admission, transfer to a different level of care, or unexpected death occurred in 56 (6.0%), 6 (0.6%), and 5 (0.5%) patients, respectively. The incidence of adverse events was greatly increased in cases where triage criteria were not met (Table 3).

Table 2. Baseline characteristics

	Triage criteria fulfilled (n = 825)	Triage criteria not met (n = 104)
Age (years)	573 (69.5)	69.1
Male gender [*n* (%)]	454 (55.0)	53.8
COVID-19 diagnosed		
before ED visit [*n* (%)]	544 (65.8)	66 (63.5)
in the ED [*n* (%)]	281 (34.1)	38 (36.5)
Method of diagnosis		
antigen test [*n* (%)]	356 (43.1)	44 (42.3)
PCR test [*n* (%)]	243 (29.5)	32 (30.8)
Initial management		
outpatient treatment [*n* (%)]	161 (19.5)	46 (44.2)
standard ward (%)	520 (63.00)	49 (47.1)
intensive care unit (%)	144 (17.5)	9 (8.7)
Time of ED stay (min)	12.15 ± 10.82	12.87 ± 11.17

Note: ED – Emergency Department; PCR – polymerase chain reaction.

Table 3. Incidence of adverse events

All adverse events				
	Number of patients	Number of adverse events	Risk ratio	*p*
Triage criteria fulfilled	825	27 (3.2%)	11.7 (7.4–18.7)	<0.001
Triage criteria not met	104	40 (38.4%)		
Unscheduled hospitalization within 48 hours				
	Number of patients*	Number of adverse events	Risk ratio	*p*
Triage criteria fulfilled	161	21 (13.1%)	5.8 (3.8–8.3)	<0.001
Triage criteria not met	46	35 (76.1%)		
Unscheduled intrahospital transfer within 48 hours or hospital discharge				
	Number of patients**	Number of adverse events	Risk ratio	*p*
Triage criteria fulfilled	664	3 (0.5%)	11.4 (2.3–57.7)	=0.036
Triage criteria not met	58	3 (5.2%)		
Unexpected death within 48 hours				
	Number of patients	Number of adverse events	Risk ratio	*p*
Triage criteria fulfilled	825	3 (0.4%)	5.3 (0.6–38.4)	=0.499
Triage criteria not met	104	2 (1.9%)		

Note: * Only patients initially intended for outpatient treatment were included. ** Only patients initially intended for hospitalization were included.

Discussion

The presented study was conducted in the unique period of a rapid spread of COVID-19, little affected by vaccination, post-exposition acquired immune reaction, or effective pharmacotherapy. Despite the immense burden placed on the health system, this situation offered a unique opportunity to test procedures for managing serious infections.

The presented algorithm proved to be safe and highly efficient. If the algorithm was used correctly, the return rate was low (13.1%). The incidence of unexpected death was also low (0.4%). Considering the unpredictable course of the disease in individual patients, with lower respiratory tract involvement often occurring later in the course of this complicated disease, we consider the aforementioned rate to be acceptable. The study was not intended to show mortality benefits for triaged patients. However, significant time savings are essential to avoid crowding and maintain quality of care for non-COVID patients (Jones et al., 2022). We also see a great benefit of rapid discharge or isolation of patients with proven COVID-19 in minimizing contact with COVID-19 negative patients and medical personnel (Chu et al., 2020; Guo et al., 2022).

The alarming difference in management of correctly triaged and mis-triaged patients – especially the 76% risk of early unscheduled hospital admission – highlights the dangers caused by the failure to follow established procedures in the management of COVID-19 patients.

The high admission rate and long hospital stay indicate high severity in the study population. This correlates with the exceptional severity of the outbreak. During the evaluated period, COVID-19 was diagnosed by RT-PCR in 18.3% of local residents. Therefore, we consider the outbreak to be exceptionally serious.

Despite the significant reduction in emergency department workload, the triage did not lead to an increase in numbers of hospital or ICU admissions. The proportion of COVID-19 positive patients requiring hospitalization in the district was lower than in the rest of the country and the world (6.4% vs. 8.0% and 4–14%, respectively). The proportion of patients indicated for ICU treatment was higher than in the rest of country, but comparable to the rest of the world (2.1% vs. 1.5% and 1–5%, respectively) (Epidemiology Working Group for NCIP Epidemic Response..., 2020; Komenda et al., 2020; Salzberger et al., 2020). This might be due to the tertiary character of the hospital, but also the impact of the triage scheme. Due to differences in the spectrum of patients and local conditions, it is impossible to accurately compare the lethality of COVID-19 with other national health centers. The fact that the lethality in the district was lower than in the rest of the country (1.3% vs. 1.8%) (Komenda et al., 2020) does not lead to any suspicion of a negative effect of triage on the overall prognosis of patients.

The use of the algorithm was one of the factors that made it unnecessary to reduce the care of acute patients (both COVID-19 positive and negative). The feasibility of the triaging algorithm was conditioned by the postponement of non-emergency medical interventions and surgical procedures in order to maintain hospital capacity for COVID-19 positive patients (Cao et al., 2020). Failure to ensure free hospital capacity would soon lead to the failure of any emergency care system (Savioli et al., 2022).

Triage and COVID-19

Triage was a widely discussed topic during the COVID-19 pandemic, with many ambiguous and misleading concepts. Several reviews have shown that out of thousands of articles related to COVID-19 and triage, most contain only statements, policy papers, public recommendations, and standard operating procedures based on little to no evidence (Alemi et al. 2023; Roque Mazoni et al., 2022; Vinay et al., 2021). The remaining scientific papers addressed several different strategies.

Triage strategies in healthcare services involved various examinations, including questionnaires and scales such as the Brescia-COVID Respiratory Severity Scale (BCRSS)/Algorithm, Identify-Isolate-Inform (3I) Tool, and Early Warning Score

(EWS) (Duca et al., 2020; Koenig et al., 2020; Swiss Society Of Intensive Care Medicine, 2020). Most triage schemes were focused on rapid identification of COVID-19 positive patients, based either on epidemiological characteristics (de Lusignan et al., 2020; Espinoza et al., 2020; Jin et al., 2020; Pediatric Branch of Hubei Medical Association..., 2020) or clinical presentation (Bonavita et al., 2020; Koenig et al., 2020; Levy et al., 2020; Poon et al., 2020). We identified only one other study intending to use a triage algorithm as a hospitalization indication tool. The algorithm based on symptoms and vital signs introduced by Fishera et al. (2022) was also successful in determining outpatient management vs. hospitalization. This algorithm included signs of lower respiratory tract involvement (dyspnea; sat <92%; breathing frequency >25/min), and clinical signs of instability (fever; inability to walk; immunosuppression; age >70 years). The rate of return in the outpatient group was low (14.3%) and only 6% of hospitalized patients had to be discharged within 48 hours.

The algorithm is similar to our scheme, and results are consistent with our data, suggesting that rapid triage is a safe and effective tool for determining the method of treatment.

Other triage schemes were used for the detection of suspected COVID-19 during home visits (Mark et al., 2020), at airports or on ships (Quilty et al., 2020), or for mass population screening, drive-through screening, *etc.* (Clemency et al., 2020; Kim and Lee, 2020). Remote digital technologies were also successfully used as triage tools for detection of suspected COVID-19, especially in high-risk populations (Bonavita et al., 2020; Espinoza et al., 2020; Farzandipour et al., 2023). However, none of those schemes intended to use triage as a tool to determine patients' treatment.

Our study and many other studies have demonstrated the benefits of various forms of triage. We suggest that in case of future outbreak of serious infection, medical authorities should declare the need of triage and its benefits. This should minimize public confusion and the fear of healthcare restrictions often associated with medical triage.

Study limitations

The main limitation of the study is its single center retrospective design. The study was conducted during a period when the predominant SARS-CoV-2 strain was the wild strain and alpha strain. At present, we can assume less frequent incidence of severe cases, with lower risk of emergency department crowding.

We cannot completely exclude the possibility that deteriorating outpatients presented to other caregivers, but we consider this unlikely as there is no other hospital in the whole district and the movement of residents was restricted during lockdown.

Conclusion

The proposed algorithm for triage of patients with proven COVID-19 is a simple, fast, and reliable tool for rapid sorting into outpatient treatment, hospitalization on a standard ward, or ICU care. However, it is highly dependent on strict adherence to the triage algorithm.

Author contributions

MJ, TV, PP, and PG wrote the manuscript. *MJ, JB, VP*, and *JK* developed the triage algorithm. *PP* and *JS* analyzed national registries and compared them to study data. *MC* prepared study tables. JV was responsible for statistical analysis. *JMH* was responsible for study coordination and funding. All authors reviewed the manuscript.

Availability of data

Data is available from the corresponding author upon reasonable request.

Ethics approval and consent to participate

This study was approved by local ethical committee (Ethics Committee of University Hospital in Hradec Králové, accredited by the Office for Human Research Protections under the number IORG0008813). Waiver for individual informed consent was granted by the same ethics committee due to the retrospective nature of the study. All methods were carried out in accordance with relevant guidelines and regulations.

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Conflict of interest

The authors have no conflict of interest to declare.

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