Tocilizumab in Hospitalized Patients with Severe COVID-19: An Open Label, Prospective Study

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Research

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Abstract

Background: Data on the safety and efficacy profile of tocilizumab in patients with severe COVID-19 needs to be enriched.

Methods: In this open label, prospective study, we evaluated clinical outcomes in consecutive patients with COVID-19 and $\text{PaO}_2/\text{FiO}_2 < 200$ receiving tocilizumab plus usual care versus usual care alone. The primary outcome was 28-day mortality. Secondary outcomes included time to discharge, change in $\text{PaO}_2/\text{FiO}_2$ at day 5 and change in WHO progression scale at day 10.

Findings: Overall, 114 patients were included in the analysis (tocilizumab plus usual care: 56, usual care: 58). Allocation to usual care was associated with significant increase in 28-day mortality compared to tocilizumab plus usual care [Cox proportional-hazards model: HR: 3.34, (95%CI: 1.21 to 9.30), ($p=0.02$)]. There was not a statistically significant difference with regards to hospital discharge over the 28-day period for patients receiving tocilizumab compared to usual care [11.0 days (95%CI: 9.0 to 16.0) vs 14.0 days (95%CI: 10.0 to 24.0), HR: 1.32 (95%CI: 0.84 to 2.08), $p=0.21$]. $\Delta\text{PaO}_2/\text{FiO}_2$ at day 5 was significantly higher in the tocilizumab group compared to the usual care group [42.0 (95%CI: 23.0 to 84.7) vs 15.8 (95%CI: -19.4 to 50.3), $p=0.03$]. ΔWHO scale at day 10 was significantly lower in the tocilizumab group compared to the usual care group (-0.5 ± 2.1 vs 0.6 ± 2.6 , $p=0.005$).

Conclusion: This is the first study administrating tocilizumab in patients with COVID-19 based on $\text{PaO}_2/\text{FiO}_2$. Tocilizumab improved survival and other clinical outcomes in hospitalized patients with COVID-19 and $\text{PaO}_2/\text{FiO}_2 < 200$ irrespective of systemic inflammatory markers levels.

Introduction

The spread of 2019 coronavirus disease (COVID-19) and the associated acute respiratory distress syndrome (ARDS) are responsible for the worst public health crisis of the latest century[1]. Despite major advances in the management of COVID-19, a considerable proportion of infected individuals experiences critical illness with hypoxic respiratory failure requiring prolonged ventilatory support[2–4]. Hypoxic respiratory failure in patients with COVID-19 has been associated with release of pro-inflammatory cytokines including interleukin (IL)-6[5]. IL-6 has been implicated in endothelial and vascular dysfunction by inducing acute phase reactants such as C reactive protein (CRP), hepcidin and fibrinogen from hepatocytes, as well as through induction of T cell differentiation and antibody production[6, 7]. Higher levels of IL-6 have been associated with COVID-19 severity[8].

A growing body of evidence support the concept of an excessive host inflammatory response leading to critical illness and increased mortality. In line with this, low doses of corticosteroids have been the only, so far, therapeutic approach that consistently improve survival across multiple studies [2, 9, 10]. Tocilizumab is a recombinant, humanized anti-IL-6 receptor monoclonal antibody initially launched as an intravenous treatment for rheumatoid arthritis, giant cell arteritis and chimeric antigen receptor T-cell-

induced severe cytokine release syndrome[11–13]. The largest to date study, denominated RECOVERY trial, showed survival benefit for patients with COVID-19 receiving tocilizumab versus usual care alone [14]. However, other studies yielded rather contradictory results [14–22]. Inclusion criteria might be major contributors of this discrepancy. In particular, administration of tocilizumab in all hospitalized patients irrespective of disease severity may have diluted any potential therapeutic effects in specific subpopulations of patients, including critically-ill patients. In addition, using arbitrary values of non-specific inflammatory markers such as CRP to tailor therapeutic approaches and prioritize patients for treatment has yielded poor results, so far. Timing from clinical presentation to treatment varied among trials and thus there was an unmet need to address whether timing of administration influences the efficacy of tocilizumab.

Our aim was to prospectively investigate the safety and efficacy profile of tocilizumab administration at the time point that $\text{PaO}_2/\text{FiO}_2 < 200$ was observed in hospitalized patients with COVID-19 irrespective of CRP and other markers of systemic inflammation.

Methods

Trial design and oversight

We conducted an open-label, prospective study enrolling consecutive patients with positive PCR for SARS-CoV-2 admitted to our hospital between 15/2/2021 and 21/4/2021. Trial sites were two separate COVID-19 departments of University Hospital of Patras, Greece. Patients were assigned to one of the two departments on 1:1 ratio following examination in the emergency unit. Patients aged 18 years or older that presented with $\text{PaO}_2/\text{FiO}_2 < 200$ at any time during their hospitalization were included in the analysis irrespective of values in inflammatory markers, such as CRP and ferritin. Exclusion criteria were: age < 18 years, pregnancy and application of mechanical ventilation prior patients' transfer to our Hospital. Each patient or the patient's legally authorized representative provided written or witnessed oral informed consent. The trial was conducted in accordance with the International Conference on Harmonisation E6 guidelines for Good Clinical Practice, the Declaration of Helsinki and the local regulations. Our study was approved by our Institutional Review Board and the Local Ethics Committee (Protocol Number: 9273/06-04-21).

Day 1 was considered the first day when a patient reached a $\text{PaO}_2/\text{FiO}_2 < 200$. Depending on the department assigned, patients with $\text{PaO}_2/\text{FiO}_2 < 200$ received usual care alone (department 1) or tocilizumab plus usual care (department 2). Tocilizumab was administered intravenously (IV) at 5mg/kg the first day that patients presented with $\text{PaO}_2/\text{FiO}_2 < 200$ (day 1). All patients included in the analysis received dexamethasone at a dose of 6mg/day. Usual care also included antibiotic compounds, antiviral compounds (remdesivir), vasopressor support and anticoagulants that were provided at the discretion of the clinicians. The study design is summarized in Fig. 1.

Outcome measures

Our primary end point was mortality by day 28. Our secondary outcomes were time to discharge and disease progression in multiple time points, as indicated by change in $\text{PaO}_2/\text{FiO}_2$ [$\Delta\text{PaO}_2/\text{FiO}_2$ (day 5 - day 1)] at day 5 and change in WHO clinical progression scale at day 10 [ΔWHO scale (day 10 - day 1)]. Towards this direction, we recorded $\text{PaO}_2/\text{FiO}_2$ of each patient, as well as demographics, smoking status, comorbidities, complete blood count, biochemical parameters, WHO clinical progression scale, time to discharge and time to event (mortality). WHO clinical progression scale provided a measure of illness severity across a range from 0 (not infected) to 10 (dead) with data elements that are rapidly obtainable from clinical records[23]. The incidence and severity of adverse events were also evaluated. These events were determined according to the National Cancer Institute Common Terminology Criteria for Adverse Events, version 5.0.

Statistical Analysis

Continuous data were denoted as mean $\pm$ standard deviation (SD) or medians with 95% Confidence Interval (95% CI) following Kolmogorov-Smirnov test for normality. The primary outcome was estimated with the Kaplan–Meier method and cumulative incidence curves were compared between the two groups. The stratified Cox proportional-hazards model was used to estimate the hazard ratio and 95% CI. Time-to-discharge secondary outcome was compared between the two groups with the use of the Kaplan–Meier approach and cumulative incidence curves were compared between the two groups. We assigned the ‘worst outcome’ for individuals who died before day 28 and thus these patients were right-censored at the longest hospital stay [24]. Mann Whitney or t-test were used for the investigation of differences in $\Delta\text{PaO}_2/\text{FiO}_2$ and ΔWHO scale between the two groups based on the absence or presence of normality. $\Delta\text{PaO}_2/\text{FiO}_2$ at day 5 was measured only for patients receiving the same method of oxygen therapy [Conventional oxygen therapy, High-flow nasal cannula, Continuous-Positive Airway Pressure (C-PAP)] during the first 5 days in order to avoid erroneous interpretations from the effect of positive end expiratory pressure (PEEP). The Kaplan–Meier method was used to assess the prognostic performance of $\Delta\text{PaO}_2/\text{FiO}_2$ at day 5. In particular, patients were split by the median value of $\Delta\text{PaO}_2/\text{FiO}_2$ at day 5 irrespective of treatment. Subsequently, the Kaplan-Meier method estimated survival probability in the high versus low $\Delta\text{PaO}_2/\text{FiO}_2$ group. p-values < 0.05 were considered statistically significant. Results were illustrated in tables and figures.

Results

Patients

Three hundred sixty patients ($n = 360$) patients were assigned in both departments during the study period. Eleven patients ($n = 11$) met the exclusion criteria. Three hundred forty-nine patients ($n = 349$) were eligible for assessment. Among patients eligible for assessment, 114 (32.7%) presented with $\text{PaO}_2/\text{FiO}_2 < 200$ during hospitalization and were included in the analysis. Fifty-six ($n = 56$) patients were assigned to receive tocilizumab plus usual care and 58 were assigned to receive usual care (Fig. 1). The majority of patients were men in both groups [tocilizumab group: $n = 33$ (58.9%), usual care group: $n = 36$ (62.1%)].

Median age was 66.0 years (95% CI: 60.0 to 70.0) and 66.5 years (95% CI: 62.1 to 72.0) for tocilizumab and usual care group, respectively. Baseline demographic and disease characteristics were generally balanced between the two groups (Table 1).

Table 1
Characteristics of the Patients at Baseline.

Characteristics	Tocilizumab Group (N, %)	Usual Care Group (N, %)
Number of patients	56	58
Age (median, %95 CI)	66.0 (60.0 to 70.0)	66.5 (62.1 to 72.0)
Male sex/Female sex	33 (58.9%)/23 (41.1%)	36 (62.1%)/22 (37.9%)
Current/ Ex-smokers/Never smokers	5 (8.9%)/18 (32.1%)/33 (58.9%)	10 (17.2%)/ 13 (22.4%)/35 (60.3%)
Arterial hypertension	29 (51.8%)	25 (43.1%)
Dyslipidemia	17 (30.3%)	7 (12.1%)
Diabetes mellitus	13 (23.2%)	14 (24.1%)
Depression	11 (19.6%)	6 (10.3%)
Obesity	9 (16.1%)	6 (10.3%)
Hypothyroidism	8 (14.3%)	6 (10.3%)
Chronic heart disease	6 (10.7%)	11 (18.9%)
Cancer	4 (7.1%)	6 (10.3%)
WHO clinical progression scale day1(mean ± SD)	5.3 ± 0.5	5.1 ± 0.5
PaO ₂ /FiO ₂ day 1 (median, 95% CI)	154.5 (130.0 to 165.0)	157.0 (131.9 to 162.9)
C-reactive protein (mg/dL, median, 95% CI)	7.5 (4.7 to 9.6)	8.5 (6.5 to 11.5)
D-dimer (µg/ml, median,95% CI)	0.82 (0.61 to 1.18)	0.84 (0.65 to 1.19)
Ferritin (ng/ml, median, 95% CI)	765.0 (545.5 to 1191.9)	644.5 (493.3 to 837.1)
White blood cells (/µL,median,95% CI)	6190.0 (5467.9 to 6882.2)	5915.0 (5400.0 to 7657.2)
Polymorphonuclear leukocytes (/µL, median, 95% CI)	4565.0 (3936.7 to 5857.0)	815.0 (692.7 to 920.0)
Lymphocytes (/µL, median, 95% CI)	5120.0 (4319.9 to 5688.0)	14.0 (13.4 to 15.1)
RDW (% , median, 95% CI)	735.0 (654.0 to 818.0)	14.2 (13.5 to 14.4)
Abbreviations: CI: Confidence Interval, COPD: Chronic Obstructive Pulmonary Disease, RDW: Red cell distribution width, SD: Standard Deviation.		

Primary efficacy outcome

The cumulative percentage of patients who reached the endpoint of mortality by day 28 was significantly lower in the tocilizumab group (16.1%) than in the usual care group (32.8%) [Cox proportional-hazards model for survival probability: HR: 3.34, (95% CI: 1.21 to 9.30), (p = 0.02)]. Results are shown in Table 2, Fig. 2A and Fig. 3.

Table 2
Primary and secondary efficacy outcomes by day 28.

Efficacy outcomes	Tocilizumab Group (N = 56)	Usual Care Group (N = 58)	p value
Primary outcome			
<i>Mortality (patients: N, %)</i>	9 (16.1%)	19 (32.8%)	0.03
Secondary outcomes			
<i>Time to discharge (days)/ patients discharged alive by day 28 (N, %)</i>	11.0 (95% CI: 9.0 to 16.0)/ 39 (69.6%)	14.0 (95% CI: 10.0 to 24.0)/ 36 (62.1%)	0.21 0.03
$\Delta PaO_2/FiO_2$ (Day 5- Day1)	42.0 (23.0 to 84.7)	15.8 (-19.4 to 50.3)	0.005
ΔWHO scale (Day 10- Day 1)	-0.5 $\pm$ 2.1	0.6 $\pm$ 2.6	

Secondary efficacy outcomes

The median time to hospital discharge over the 28-day period was 11.0 days (95% CI: 9.0 to 16.0) in the tocilizumab group and 14.0 days (95% CI: 10.0 to 24.0) in the usual care group [HR: 1.32 (95% CI: 0.84 to 2.08), p = 0.21] (Fig. 2B). Thirty nine (n = 39, 69.6%) and 36 patients (62.1%) had been discharged alive by day 28 in the tocilizumab and usual care group, respectively (Table 2). Eleven (n = 11, 19.6%) and 14 patients (24.1%) received mechanical ventilation by day 28 in the tocilizumab and usual care group, respectively.

ΔWHO scale at day 10 was significantly lower in the tocilizumab group compared to the usual care group (-0.5 $\pm$ 2.1 vs 0.6 $\pm$ 2.6, p = 0.005), (Supplemental Fig. 1A). $\Delta PaO_2/FiO_2$ at day 5 was measured only for patients receiving the same method of oxygen therapy during the first 5 days (n = 83). $\Delta PaO_2/FiO_2$ at day 5 was significantly higher in the tocilizumab group compared to the usual care group [42.0 (95% CI: 23.0 to 84.7) vs 15.8 (95% CI: -19.4 to 50.3), p = 0.03], (Supplemental Fig. 1B).

In the overall population, median $\Delta PaO_2/FiO_2$ at day 5 was 35 (95% CI: 16.9 to 60.0). Kaplan-Meier analysis in the overall population irrespective of treatment arm demonstrated higher all-cause mortality in

patients with high (≥ 35) vs. low $\Delta\text{PaO}_2/\text{FiO}_2$ at day 5 (< 35), [HR 3.70 (95% CI:1.24 to 11.00), ($p = 0.03$)], (Supplemental Fig. 2).

Adverse events

Adverse events by day 28 were comparable between the two groups. In particular, 3 patients (5.4%) presented with lobar consolidation, while cardiac event and bleeding occurred in 1 patient (1.8%) in the tocilizumab group. Two patients (3.4%) presented with lobar consolidation, while cardiac event and bleeding occurred in 1 patient (1.7%) in the usual care group (Table 3).

Table 3
Adverse events by day 28.

Adverse events	Tocilizumab Group (N = 56)	Usual Care Group (N = 58)
Lobar consolidation	3 (5.4%)	2 (3.4%)
Cardiac Event	1 (1.8%)	1 (1.7%)
Bleeding	1 (1.8%)	1 (1.7%)
Septic shock	0 (0%)	0 (0%)

Discussion

To the best of our knowledge, this is the first study aiming to address the question whether administration of tocilizumab at the time point that $\text{PaO}_2/\text{FiO}_2 < 200$ was observed influences its efficacy. We included a homogenized population of patients with severe COVID-19 and administered tocilizumab at the time of clinical and physiological deterioration, as assessed by $\text{PaO}_2/\text{FiO}_2 < 200$ irrespective of levels of non-specific inflammatory markers including CRP and ferritin. Treatment with tocilizumab improved survival and slowed down disease progression as indicated by changes in $\text{PaO}_2/\text{FiO}_2$ and WHO progression scale. Administration of tocilizumab at the time point of clinical and physiological deterioration deserves further investigation to tailor therapeutic approaches and identify those individuals who will most likely benefit from IL-6R antagonists.

Evidence from several relatively-small studies followed by meta-analyses yielded contradictory results on the safety and efficacy profile of tocilizumab in patients with COVID-19. In particular, a meta-analysis of the first eight randomized controlled trials (RCTs) ($n = 2733$) of tocilizumab failed to show a survival benefit [14–22]. On the contrary, the REMAP-CAP study, enrolling an overall of $n = 803$ critically ill COVID-19 patients demonstrated improved clinical outcomes compared to placebo [21]. The EMPACTA trial, recruiting patients with COVID-19 ($n = 389$) and blood oxygen saturation below 94%, showed reduced likelihood of progression to mechanical ventilation or death, but failed to reach significance on disease

survival[18]. Most importantly, the largest so far tocilizumab study, the RECOVERY trial, encompassing an overall of 4116 patients, further enriched the beneficial effects of tocilizumab in all three primary end-points of hospitalization, survival and need for mechanical ventilation. Improved clinical outcomes were observed irrespective of the level of respiratory support[14].

The above contradictory results might be explained by several characteristics of the trials including heterogeneous enrollment criteria such as disease severity, timing of administration and concurrent use of corticosteroids[25]. Inclusion of patients with varying degree of disease severity might be linked with different degrees of inflammation with those being at the most advanced stage being these with the highest inflammatory status and thus expected to benefit more from anti-inflammatory interventions. On the other hand, patients at the most severe disease status with prolonged time since onset of symptoms may not benefit accordingly because inflammatory cascade may be too advanced to be reversible. The peak of the SARS-CoV-2 mediated inflammatory response often coincides with clinical deterioration [26]. Once the inflammatory cascade reaches a state of hyperactivation, it might be too late to intervene, and thus it has been suggested a time window within which IL-6R antagonists will be most beneficial. This window might correlate with the time around clinical deterioration, perhaps when organ dysfunction is more reversible [25]. Therefore, appropriate timing seems to be the most crucial contributor of treatment success. Based on the current literature, there was an unmet need to address the question whether timing of administration influences the efficacy of tocilizumab, as previous reports suggested that administration around the time of clinical deterioration might improve clinical outcomes; yet, none of the studies, so far, have been designed to confidently answer this question[25].

Our study exhibited a number of important attributes by addressing these clinical sources of heterogeneity. In particular, tocilizumab was applied exactly at the time of clinical and physiological deterioration, as assessed by $\text{PaO}_2/\text{FiO}_2$ lower than 200, in a homogenized group of patients presenting with severe disease and concurrent use of corticosteroids. Cox proportional-hazards model showed that tocilizumab was efficacious irrespective of baseline condition; thus, some slight differences in baseline characteristics of the two groups did not affect outcomes. Our study results were in line with the REMAP-CAP study showing efficacy of tocilizumab across all CRP-subgroups [21]. Our data combined with others by no means support the notion that biologic enrichment of such studies will not be beneficial. Rather, we believe that biomarkers such as CRP or ferritin are neither sensitive, nor specific for treatment tailoring considering that their biologic association with lung inflammation is not linear and representative[27, 28]. On the other hand, physiological markers of local inflammation, such as $\text{PaO}_2/\text{FiO}_2$, might be more useful indicators of which patients will benefit from IL-6R antagonism [21, 29, 30]. Moreover, our approach might limit irrational use of tocilizumab and maximize cost-effectiveness. Otherwise, a dramatic upswing in prescribing will possibly challenge supply chains and health system budgets[31].

A novel finding of our study is the significant improvement of $\text{PaO}_2/\text{FiO}_2$ at day 5 for patients receiving tocilizumab plus usual care compared to usual care alone. Absence of serial data for $\text{PaO}_2/\text{FiO}_2$ was a limitation in previous RCTs of tocilizumab in COVID-19 [14]. We analyzed patients under constant method of oxygen therapy during the first 5 days of treatment initiation. In this way, we aimed to avoid

misinterpretations arising from application of heterogeneous non-invasive respiratory therapies across the same patient. Finally, in the context of adverse events, consistent result across all trials to date, including our study, is that no increased incidence of serious adverse events have been reported for patients receiving tocilizumab[14–22, 32, 33].

Our study has some limitations that need to be treated cautiously. First, it was an open label trial. Although assessment of the primary outcome is objective, secondary outcomes such as score in WHO progression scale are operator-dependent. Limitations for the use of WHO progression scale as a secondary outcome include sensitivity to differences in local clinical practice, lack of proportionality between categories and lack of an established minimum clinically important difference. Second, our sample size was moderate; yet, adequate to detect significant differences in mortality. Third, patients were randomly assigned to one of the two departments based on the time of admission in the Emergency Unit; yet this was not a randomized controlled trial. Finally, the dosage we used (5 ml/kg) is lower than that of some other trials (8ml/kg); nonetheless, this dosage is within the range of the recommended tocilizumab dose (4–8 ml/kg). The concept that lower doses of tocilizumab might retain effectiveness and spare adverse events deserves further investigation.

Conclusions

Collectively, the results of this open label, prospective study demonstrated that tocilizumab is an effective treatment for hospitalized patients with COVID-19 when administered at the time of clinical and physiological deterioration, as indicated by $\text{PaO}_2/\text{FiO}_2 < 200$. Improved clinical outcomes were observed across all treated patients irrespective of the magnitude of inflammation. Implementation of physiological markers of disease severity coupled with biological enrichment could help us identify the ideal time point and subgroup of patients with COVID-19 for optimal therapeutic and safety effects.

Declarations

Ethics committee approval: Our study was approved by our Institutional Review Board and the Local Ethics Committee (Protocol Number: 9273/06-04-21). This is not a registered report. This is not a randomized controlled trial.

Consent for publication: Consent for publication by all authors.

Availability of data and materials: The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Competing interests: none to declare.

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Contributors - Author contribution statement:

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References

1. Guan, W.-j., et al., *Clinical Characteristics of Coronavirus Disease 2019 in China*. New England Journal of Medicine, 2020.
2. RECOVERY Collaborative Group; P. Horby , W.S.L., J.R. Emberson , M. Mafham , J.L. Bell, L. Linsell, N. Staplin , C. Brightling , A. Ustianowski, E. Elmahi, B. Prudon, C. Green , T. Felton , D. Chadwick , K. Rege, C. Fegan , L.C. Chappell , S.N. Faust , T. Jaki , K. Jeffery , A. Montgomery , K. Rowan , E. Juszczak , J.K. Baillie , R. Haynes , M.J. Landray, *Dexamethasone in Hospitalized Patients with Covid-19*. New England Journal of Medicine, 2020. **384**(8): p. 693-704.
3. Karampitsakos, T., et al., *Increased Red Cell Distribution Width Is Associated With Disease Severity in Hospitalized Adults With SARS-CoV-2 Infection: An Observational Multicentric Study*. Front Med (Lausanne), 2020. **7**: p. 616292.
4. <https://www.covid19treatmentguidelines.nih.gov/overview/clinical-spectrum/>.
5. Del Valle, D.M., et al., *An inflammatory cytokine signature predicts COVID-19 severity and survival*. 2020. **26**(10): p. 1636-1643.
6. Tanaka, T., M. Narazaki, and T. Kishimoto, *IL-6 in inflammation, immunity, and disease*. Cold Spring Harb Perspect Biol, 2014. **6**(10): p. a016295.
7. Pons, S., et al., *The vascular endothelium: the cornerstone of organ dysfunction in severe SARS-CoV-2 infection*. Crit Care, 2020. **24**(1): p. 353.
8. Aziz, M., R. Fatima, and R. Assaly, *Elevated interleukin-6 and severe COVID-19: A meta-analysis*. J Med Virol, 2020. **92**(11): p. 2283-2285.
9. Mehta, P., et al., *COVID-19: consider cytokine storm syndromes and immunosuppression*. Lancet, 2020. **395**(10229): p. 1033-1034.
10. Xu, X. and M. Han, *Effective treatment of severe COVID-19 patients with tocilizumab*. 2020. **117**(20): p. 10970-10975.
11. Yazici, Y., et al., *Efficacy of tocilizumab in patients with moderate to severe active rheumatoid arthritis and a previous inadequate response to disease-modifying antirheumatic drugs: the ROSE study*. Annals of the Rheumatic Diseases, 2012. **71**(2): p. 198-205.

12. Si, S. and D.T. Teachey, *Spotlight on Tocilizumab in the Treatment of CAR-T-Cell-Induced Cytokine Release Syndrome: Clinical Evidence to Date*. 2020. **16**: p. 705-714.
13. Karampitsakos, T., et al., *Biologic Treatments in Interstitial Lung Diseases*. Front Med (Lausanne), 2019. **6**: p. 41.
14. RECOVERY, *Tocilizumab in patients admitted to hospital with COVID-19 (RECOVERY): a randomised, controlled, open-label, platform trial*. Lancet, 2021. **397**(10285): p. 1637-1645.
15. Stone, J.H., et al., *Efficacy of Tocilizumab in Patients Hospitalized with Covid-19*. New England Journal of Medicine, 2020. **383**(24): p. 2333-2344.
16. Soin, A.S., et al., *Tocilizumab plus standard care versus standard care in patients in India with moderate to severe COVID-19-associated cytokine release syndrome (COVINTOC): an open-label, multicentre, randomised, controlled, phase 3 trial*. Lancet Respir Med, 2021. **9**(5): p. 511-21.
17. Veiga, V.C., et al., *Effect of tocilizumab on clinical outcomes at 15 days in patients with severe or critical coronavirus disease 2019: randomised controlled trial*. BMJ, 2021. **372**: p. n84.
18. Salama, C., et al., *Tocilizumab in Patients Hospitalized with Covid-19 Pneumonia*. N Engl J Med, 2021. **384**(1): p. 20-30.
19. Rosas, I.O., et al., *Tocilizumab in Hospitalized Patients with Severe Covid-19 Pneumonia*. New England Journal of Medicine, 2021. **384**(16): p. 1503-1516.
20. Hermine, O., et al., *Effect of Tocilizumab vs Usual Care in Adults Hospitalized With COVID-19 and Moderate or Severe Pneumonia: A Randomized Clinical Trial*. JAMA Internal Medicine, 2021. **181**(1): p. 32-40.
21. Gordon, A.C. and P.R. Mouncey, *Interleukin-6 Receptor Antagonists in Critically Ill Patients with Covid-19*. New England Journal of Medicine, 2021. **384**(16): p. 1491-1502.
22. Salvarani, C., et al., *Effect of Tocilizumab vs Standard Care on Clinical Worsening in Patients Hospitalized With COVID-19 Pneumonia: A Randomized Clinical Trial*. JAMA Internal Medicine, 2021. **181**(1): p. 24-31.
23. WHO, *A minimal common outcome measure set for COVID-19 clinical research*. Lancet Infect Dis, 2020. **20**(8): p. e192-e197.
24. Rahman, S., et al., *Bias due to censoring of deaths when calculating extra length of stay for patients acquiring a hospital infection*. BMC Med Res Methodol, 2018. **18**(1): p. 49.
25. Angriman, F., et al., *Interleukin-6 receptor blockade in patients with COVID-19: placing clinical trials into context*. Lancet Respir Med, 2021. **9**(6): p. 655-664.

26. Manson, J.J., et al., *COVID-19-associated hyperinflammation and escalation of patient care: a retrospective longitudinal cohort study*. Lancet Rheumatol, 2020. **2**(10): p. e594-e602.
27. Fajgenbaum, D.C. and C.H. June, *Cytokine Storm*. 2020. **383**(23): p. 2255-2273.
28. Sinha, P., et al., *Prevalence of phenotypes of acute respiratory distress syndrome in critically ill patients with COVID-19: a prospective observational study*. Lancet Respir Med, 2020. **8**(12): p. 1209-1218.
29. Gu, Y., et al., *PaO₂/FiO₂ and IL-6 are risk factors of mortality for intensive care COVID-19 patients*. Scientific Reports, 2021. **11**(1): p. 7334.
30. Dorward, D.A. and C.D. Russell, *Tissue-Specific Immunopathology in Fatal COVID-19*. 2021. **203**(2): p. 192-201.
31. Murthy, S. and T.C. Lee, *IL-6 blockade for COVID-19: a global scientific call to arms*. Lancet Respir Med, 2021. **9**(5): p. 438-440.
32. Tomasiewicz, K., et al., *Tocilizumab for patients with severe COVID-19: a retrospective, multi-center study*. 2021. **19**(1): p. 93-100.
33. Campochiaro, C., et al., *Efficacy and safety of tocilizumab in severe COVID-19 patients: a single-centre retrospective cohort study*. Eur J Intern Med, 2020. **76**: p. 43-49.

Figures

Figure 1

Schematic representation of the study design.

No. at risk
Tocilizumab
Usual Care

A.

No. at risk
Tocilizumab
Usual Care

B.

Figure 2

Allocation to usual care was associated with significant increase in 28-day mortality compared to tocilizumab plus usual care [Cox proportional-hazards model: HR: 3.34, (95% CI: 1.21 to 9.30), (p=0.02)], (Panel A). There was not a statistically significant difference with regards to hospital discharge over the 28-day period for patients receiving tocilizumab compared to usual care [11.0 days (95% CI: 9.0 to 16.0) vs 14.0 days (95% CI: 10.0 to 24.0), HR: 1.32 (95% CI: 0.84 to 2.08), p=0.21], (Panel B).

Figure 3

Forest plot of the primary endpoint (mortality) in prespecified subgroups. Estimates are based on a Cox proportional-hazards model.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- [SUPPLEMENTALFIGURE1.pdf](#)
- [SUPPLEMENTALFIGURE2.pdf](#)
- [SupplementarymaterialTocilizumabinCOVID19.docx](#)