

The Convalescent Plasma Therapy for COVID-19 Pandemic

Sonawane GA* and Kulkarni AD

Department of Pharmaceutics, Sanjivani collage Of Pharmaceutical Education and Research, kopargaon, Maharashtra, India

*Corresponding author: Sonawane GA, Department of Pharmaceutics, Sanjivani collage Of Pharmaceutical Education and Research, kopargaon. Maharashtra, India, Tel: +91-9139898967, E-mail: sonawanegaurav8888@gmail.com

Citation: Sonawane GA, Kulkarni AD (2020) The Convalescent Plasma Therapy for COVID-19 Pandemic. J Infect Dis Pathog 3: 103

Article history: Received: 26 May 2020, Accepted: 10 June 2020, Published: 12 July 2020

Abstract

In the remaining months of the year 2019, the pandemic, which located in China, has become a most important disaster for everywhere throughout the world. The Novel coronavirus, extreme in relation with acute respiratory syndrome Novel coronavirus two or SARS-CoV-2, has been described as the cause for an array of not known pneumonia. Hence, far, we aren't longer having a specific remedy and a vaccine has been indicated that effective against SARS-CoV-2 or Novel corona infection. With supportive care, mild cases of sufferers can be medicated even though now symptomatic treatment is not ample for severely unwell patients. Anyway, extracorporeal membrane oxygenation, convalescent plasma (CP) and the sure antiviral particular tablets for this disease are not useful this was investigated for growing the survival rate of instances with SARS-CoV-2 situation of contamination remain to worsen. The entire blood of Human is additionally a starting place of antibodies. From anyone patient who has recovered from specific contamination, CP is collected. The latest literature survey shows that human CP may additionally be an option for managing this coronavirus disease and will be viable when ample numbers of men and women have elevated or cured. However, the patient or such donors have to have a more titer of neutralizing immunoglobulin containing plasma. CP can be ingested to limit the fatality charge of COVID-19, preventive measures, together with other capsules and, when unique manage is now not achievable. Casual clinical trials are still crucial on the different way to examine the protection and effectivity of CP in the remedy of COVID-19. We prefer to tackle the distinct position of CP remedy in this article, in quite a number of infectious ailments from past to present, inclusive of COVID-19.

Keywords: Plasma Therapy; Serum; Covid-19; Antibodies

Introduction

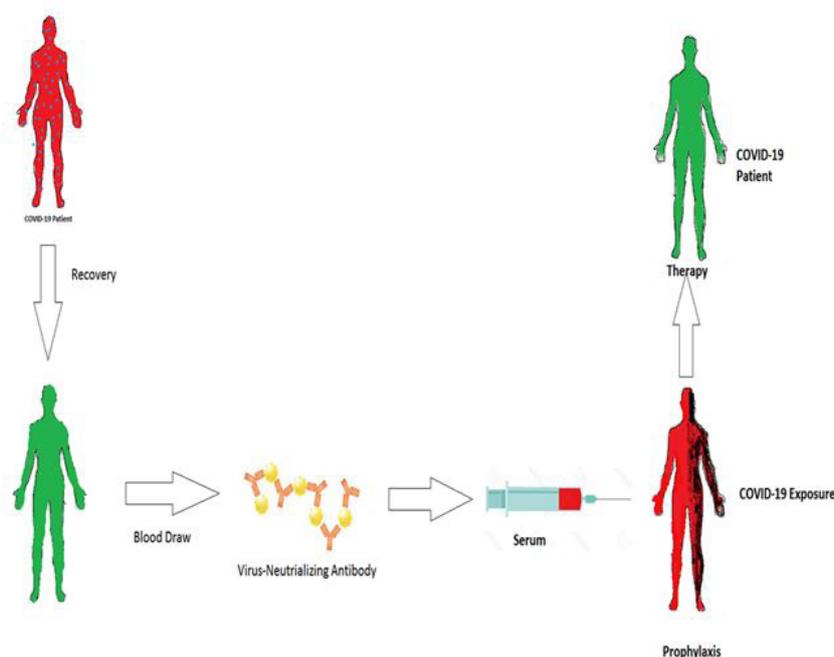


Figure 1: Schematic Diagram of the Use of CP FOR COVID-19

The (SARS-CoV-2) coronavirus 2 determined first off in Wuhan, China, and it used to be unexpectedly spread through worldwide. China had mentioned about 81767 corona fantastic patients and the deaths around 3281. The World Health Organization (WHO) declared as a pandemic to coronavirus sickness 2019 (COVID-19). This disorder then unfolds in to up to the 195 country's as of March 18, 2020 [1,2]. Till date, no any drug and vaccine is accessible for the cure of COVID-19 [3]. The use of convalescent plasma remedy used to be introduced as a very advantageous remedy for Ebola virus in 2014 and other viral diseases, and the permission for treating the coronavirus Middle East respiratory syndrome used to be given in 2015 [4]. Administration of convalescent plasma was once displaying very top consequences in evaluation with different patients who now not treated with the convalescent plasma [5]. Accordingly, these finds that use of plasma transfusion will be really helpful in COVID 19 patient.

Convalescent plasma has been used as a therapy to raise in no of people with SARS whose essential condition is in a stage in the rate of survival. A quite a few cases find out about the end result showed a shorter hospitalization and much less mortality in people who are handled with this convalescent plasma therapy in evaluation with those who had been not treated with convalescent plasma [6] (Figure 1).

What is Convalescent Plasma?

Convalescent plasma therapy includes the insertion of antibodies towards a susceptible individual with a given agent for the motive for preventing or curing an infected patient due to that agent (virus). Invariance, for active vaccination, there is a requirement of the initiation of an immune response requires time for the practice of on the vaccine recipient. Thus, the insertion of passive antibody is the only approach of offering speedy immunity for inclined persons. Convulsive plasma therapy has a superb record of the year the Nineties and used to be the sole way of treating sure infectious ailments primarily to the improvement of antimicrobial therapy in the Forties [7-9]. This remedy is a shape of passive immunization. From the entire blood liquid phase (plasma) should be taken from the individual who has survived a SARS-CoV-2 or comparable infection (The comparable infections is nothing but the, which are caused by pathogen from the same type of viruses or the same family of viruses. Which shows the similarity in the infection pattern, symptoms etc.). We suppose that this is would possibly be an excellent defensive approach to the deficient scientific journey of convalescent plasma administration into the countless ill affected person [10,11].

Quick neutralizing antibodies are given from Convalescent plasma against the viral pathogens of COVID-19 prone or contaminated patients for the prevention or remedy of contagious disease, but these immune globulins will have a very short lifetime, from a few months to perchance a few weeks. On the opposite, active vaccination having an effect of stimulation of a reaction of systemic immunity that takes time to assemble up a response varying amongst recipients; in the less immune folks or sufferers fails in to get a more advantageous immune response. Thus, the passive antibody furnishing is an only way of imparting quick immunity to unprotected human beings and any measurable variety from immunity for extraordinary patients with immune compromised [12] (Table 1).

Sr.No.	Disease Name	Sr.No.	Disease Name
1	Hepatitis	7	Poliomyelitis
2	Avian influenza A (H5N1)	8	2009 pandemic influenza A (H1N1) (influenza A [H1N1] pdm09)
3	MERS-CoV infection	9	Pneumococcal pneumonia
4	SARS coronavirus (SARS-CoV)	10	2013 West African Ebola epidemic
5	Spanish influenza A (H1N1)	11	Meningitis
6	Rabies	12	Mumps and measles

Table 1: Use of Convalescent (Immune) Blood Product (Serum/Plasma) In Historical Treatments to Treat a Variety of Infectious Illnesses

At the arrival of the twentieth century, convalescent plasma was used to stop epidemics of viral ailments like e.g., measles and mumps. Also, serum therapy used to be used as intra-spinally and subcutaneously in some patients of epidemic poliomyelitis [13-15]. Convalescent blood plasma was once additionally used in 2013 at the West African Ebola epidemic. A little nonrandomized find out about in Sierra Leone gives an extraordinarily longer survival for these given convalescent entire blood, a contrast to sufferers who take everyday management [16]. Also, there are some reviews shows about the usefulness of Convalescent plasma remedy for SARS in 2003 and core east respiratory disorder mers in 2012. In these epidemics, more fatality and deficiency of proven therapeutics led to the software of convalescent serum. Acquired from samples of the previous literature studies, convalescent plasma transfusion was once regarded for the cure of MERS-CoV infection and it used to be in fact utilized in quite a few instances all through the 2015 Korean epidemic [17].

At the end, extra than the remaining two decades, convalescent plasma remedy has been used (Table 2) in the therapy of SARS, MERS, and in 2009 influenza A H1N1 pandemic (H1N1pdm09) with adequate efficacy and protection [18,19].

Disease	Dose (volume) of convalescent plasma	COVID-19 (28, 19, 21)	Summarized findings
SARS (20-24)	-279±127 (160–640) ml	Not state	• Overall, eighty instances obtained CIP. 10 sufferers died.
	-500 mL	Antibody (IgG) titer: >640	CIP at ~14 (7–30) days following the onset of symptoms
	-200 ml	Not stated	Good medical outcome in 33 sufferers as described by hospital discharge by using day 22
	-2 units of 250 mL each (total 500 mL)	Not stated	Improved outcome with early administration No unfavourable events
MERS (25, 21, 26,27)	-4 transfusions of CIP to 3 patients; volumes not stated	1:40 or 1:80	• Questionable gain even though all three patients
	-2 units (250–350 mL/unit)	Not stated	Feasibility study to evaluate the ratio of convalescent donors having antibodies against MERS-CoV
	-250 mL	Not stated	• Case document of 1 patient Possible TRALI observed
COVID-19 (28, 19, 21)	-200 mL	Neutralizing antibody titer: >1:640	• Uncontrolled 10 severely unwell patients CIP at 16.5 (11.0–19.3) days Recovery of all patients No widespread unfavourable effect
	-2 consecutive transfusions Of 200–250 ml (400 ml total)	ELISA Anti-SARS-CoV-2–antibody Titer: >1:1000 Neutralizing antibody titer: >1:40	Uncontrolled 5 severely sick cases CIP at 10–22 days after admission Recovery of all sufferers

Table 2: Administration of the Convalescent Plasma Remedy in Coronavirus Epidemics

Convalescent Plasma and Pathogen Inactivation

Convalescent plasma therapy, in prior to antibodies, gives control of haemorrhagic events, as in ebolavirus disease, within the 24 hrs time interval if transfusion occurs in order to keep viable platelets and clotting factors. Nevertheless, convalescent plasma best fits advance nation standards and situation where antibodies have a need or required. Convalescent Plasma should be collected by dialysis in order to confirm the larger volumes, more repeated donations, so the donor should not suffer unnecessarily from anaemia [20-27].

Technologies to Virally Reduce (Pathogen Inactivation) Plasma

From the United States, Food and Drug Agency or the European Centre for Disease control are not recommending technology of pathogen reduction [28], in several situation donor screening and conventional testing of NAT (i.e. HIV, HCV and HBV NAT) may not be enough to ensure Convalescent plasma safety. Many other technologies have been permitted and are currently marketed. Solvent/detergent (S/D)-filtered plasma provides quick > 4 logs inactivation of most enveloped viruses. Although the technique was developed and is massively used for large plasma pools, small scale reduction have been reported. The technology belongs over 1% tri (n-butyl) phosphate/1% Triton X-45, removal of solvent and detergent via oil extraction and filtration, and in last stage sterile filtration [29]. Filtration around the 75–35 nm empty fibres could remove large viruses while conserving IgG [30], but has not been implemented yet.

Experiences from Sars

The SARS-CoV RNA pathogen was found in patients for up to 4 weeks following symptoms [31]. SARS-specific antibodies usually continue for 2 years [32], and decies in prevalence and titers occurs in the third year [33]. The immune globulins of Convalescent anti-SARS were manufactured on a small scale [34,35]. Three healthcare workers who are infected with SARS development for all treatment survived after inducing with 500 ml of convalescent plasma: viral load decreased one day after transfusion up to zero. Soo, *et al.* [36] reported in a retrospective nonrandomized trial that treatment with convalescent plasma (titre > 1:160) in 19 patients was related with shorter hospitalisation and lower in the mortality than in continuing high-dose of methylprednisolone [36].

Experiences from Mers

Antibody responses to MERS preserve for less than a year and size correlates with the time interval of viral RNA diffuse in sputum. Gentle patients have very low titers, making convalescent plasma collection challenging in MERS convalescents [30]. In

a study found that only 2.7% (12 out of 443) infected cases tested positive with ELISA, and about 75% of them had reactive micro neutralization assay titers [24]. Convalescent plasma with a PRNT titre $\geq 1:80$ gives a clinical advantage in MERS [36]. In the case of TRALI bellow, Convalescent plasma in a patient with MERS transfer was noted [37-40].

Current Clinical Experiences in COVID-19

When the as soon as the COVID-19 pandemic appeared [41,42], many authors recommending convalescent as a potential therapeutic technique [43,44]. Of interest, the most seriously ill patients show prolonged virus present in the blood (strongly correlated with serum IL-6 levels) [45,46], which leaves room for therapeutic involvement with antivirals and immunoglobulins even in last stages. The viral shedding in survivors can be as long as up to 37 days [42], initial SARS-CoV2 RNA screening in Convalescent plasma donors. Finding of serum IgM and IgA antibody in COVID-19 appears since day 5 after symptom onset, while IgG is identified since day 14 [47]. IgG are universally detected since day 20 [48]. Severe female patients generate IgG earlier and more titers [49]. Time interval of anti-SARSCoV2 antibodies in plasma remains unidentified, but immunity for other coronaviruses typically lasts for 6-12 months [50]. A donor which is full fill the criteria could donate 600 ml plasma (it is equivalent to 3 therapeutic doses) up to 14 days minimum from six months. Invariance to EVD, SARS, and MERS, most COVID-19 patients display few or no symptoms and do not require hospitalization, addressing that the majority of convalescent donors are best sought after in the general population.

Abbreviations: Ct-cycle threshold

ECMO- extracorporeal membrane oxygenation

NT- not tested.

- With the help of this six system SOFA score is calculated: coagulation, respiratory, hepatic, central nervous system, cardiovascular and kidney. A 0 score is given for normal working through and 4 for most anomalous for each system. The thrash values on every day are recorded. The final SOFA score is the addition of the scores of each system.
- PAO₂/FIO₂ ratio was defined as the ratio of the partial pressure of arterial oxygen to the percentage of inspired oxygen.
- Cycle threshold is the number of polymerase chain reaction cycles which is required for gene amplification. A higher Ct value is considered with a lower viral load.
- The lowest value (highest viral load) between hospital admission and plasma transfusion.

Results of Scientific Experience in COVID-19

Five patients with an age vary of from 36 to 73 years; two women were dealt with CP. From that No one is smokers, and 4 of 5 had no pre-existing medical prerequisites Convalescent plasma used to be administered between days 10 and 22 after joining [1]. After plasma transfusion of CT values of the affected person, 5 grew to become turndown on day 1, affected person three and affected person 4 suggests on day 3, and the affected person 2 and 1 became turndown on the day 12 after the blood transfusion (Table 3).

	Patient				
	1	2	3	4	5
IL-6, pg./mL (normal range, 0-7)					
Before transfusion	438.2	70.5	87.8	79.1	63.9
Day 1 post transfusion	NT	74.9	NT	39.3	118.5
Day 3 post transfusion	1045	34.5	797.9	25.8	67
Day 5 post transfusion	334.1	24.1	NT	NT	590.5
Day 7 post transfusion	29.8	30.8	69.9	34	174.3
Day 12 post transfusion	31.8	6.1	54.9	2.7	NT
Length of hospital stay, d	Remains hospitalized	Remains hospitalized	55	51	53
Current status as of March 25, 2020	The patient is stable still getting ventilation	The patient is stable still getting ventilation	Patient Discharged	Patient Discharged	Patient Discharged

Table 3: The Comparison between Viral Load, Clinical Indexes, and Laboratory Results Before and After [1] CP Transfusion

Timing and Volume (The Dose) of Convalescent (Immune)

Even with the possible convenience of passive treatment of antibody's, there have been few cooperative efforts to use them as in the preliminary treatments towards emerging and pandemic infectious threats or diseases. According to some studies, it was

contributed that doubt to appoint this treatment. Also, the most fantastic formulations like convalescent complete blood, serum or plasma, timing and administration to an extent are unknown. Depend on the antibody volume and ingredient, the safety period supplied by Convalescent Plasma can prolong from some weeks or months. For fine therapy, a sufficient quantity of Convalescent Plasma must be administered at a precise time. The time is very important because Convalescent Plasma will journey in the contact tissues, blood, and offer protection in opposition to the infection in time [12].

There is not having a piece of strong evidence about removal time of antibodies to SARS-CoV-2 from blood serum; Cao, *et al.* [51] Illustrate that the of neutralizing antibody at a particular level to SARS-CoV decline slowly 4 months previous the sickness course, accomplishing insignificant IgG ranges up to 25.6% and neutralizing antibodies in 16.1% of instances at three years following sickness restoration. Convalescent plasma cure for the ailment pneumococcal pneumonia used to be most profitable when used when at the start of manifestations once following, and there was once no gain if the treatment used to be postponed after the third day of disease onset [52]. Individual convalescent plasma gadgets display donor-dependent variants in antibody specifications and titers. MERS-CoV-infected instances showed up to 60% of the seroconversion rate without pneumonia, and 96% of pneumonia instances illustrated seroconversion. This perfection in seroconversion price indicates that donors need to be examined for antibody titers, if no longer then favoured from instances who recuperated from extreme or indispensable illness [53].

For the MERS-CoV infection to do profitable convalescent blood plasma infusion, for the donor plasma examination of neutralization and antibody workings of a PRNT (plaque discount neutralization test) titer $\geq 1:80$ would possibly be needed. Manage IgG titers via ELISA could fix for neutralization checks in brief availability [54].

An examination of ninety-nine patients of convalescent plasma from instances with SARS suggests that about 87 having a neutralizing antibody, with a mathematical suggest titer up to 1:61 [18]. In the yr 2003 SARS infestation, the results of sufferers who dealt with convalescent plasma in town Hong Kong had been examined. There had been about 1775 patients, the eighty who administered with Convalescent plasma having a decrease fatality price (12.5%) in evaluation with the ordinary SARS-related mortality for admitted patients (17%). The plasma transfusion quantity and antibody titers various and did now not visible to interpret with the medical response; although, sufferers getting a transfusion in 14 days of symptom approach had higher results [55]. Zhang, *et al.* [56] said that 4 reproving sick sufferers with SARS-CoV-2 the use of convalescent plasma remedy around 2 weeks of hospitalization. Depending on the patient, about 2400 to 200 ml was used to treat patient recover from COVID-19. Tiberghien, *et al.* [57] Advocate the insertion of two plasma phase of 200 to or about 250 ml every in instances at the day fifth of therapy varies in weight between 50 and eighty kg, quantity to be normal for instances weighing outdoor this limit.

CP Donor Enrolment Strategies

In the study, from three hospitals 10 donor patients have been enrolled who gate cured of the COVID-19. Once the entire blood from a donor was gathered up to 3 weeks after the beginning of sickness and four days after discharge. The Written knowledgeable consent structure must be obtained from each donor. At the starting, the skimming for serological hepatitis C and B virus, HIV, and syphilis, SARS-CoV-2 and RT-PCR check ought to be carried out [58,59]. To elevate out the Titration of antibodies is useful earlier than the proper use of CP for prevention and treatment. The COVID-19 sufferers who generated SARS-CoV-2-specific and spike-binding antibodies from day 10 to day 15 concurrently after infection. From total no of patients, about 30% of patients get recovered and few patients generated very lesser titers of SARS-CoV-2- precise antibodies. The middle-age and Elderly patient's recovered COVID-19 developed greater tiers of SARS-CoV-2-specific antibodies. From COVID-19 recovered instances age and SARS-CoV-2-specific antibody titers negatively correlated with lymphocyte on admission count number are positively correlated with CRP degrees. These all information above gives information about which donor is extra beneficial or fulfil the requirements for CP compilation [60].

People who fulfil all blood/plasma donor eligibility from that CP must be only collected, as well as they must fulfil the following requirements. i) Individuals should have confirmation of COVID-19 recognized by a laboratory test, including swab/RT-PCR method. ii) Minimum 14 days earlier to the donation complete improvement of indication, and negative test (swab or RT-PCR) results for COVID-19. iii) Male donors or female donors who are not pregnant or female donors checked as negative for HLA antibodies to exclude transfusion-related acute lung injury (TRALI). iv) SARS -CoV-2 neutralizing antibody titers of at least 1:160. The titer of 1:80 may be thought to be acceptable if a different appropriate unit is not present.

Patient Eligibility

In any case with extreme or quickly to crucial of laboratory-verified COVID-19 cases CP remedy can be administered. Severe sickness shows comprise dyspnea, respiratory frequency is ≥ 30 /min, oxygen saturation $\leq 93\%$, the partial stress of arterial oxygen in the fractions of stimulated oxygen ratio < 300 , and pulmonary infiltrates is $> 50\%$ in time 24-48 hours. The respiratory disappointment septic stun and disappointment of the organs are the quintessential manifestations of the sincerely sick affected person.

What are the Adverse Effects of CP Transfusion?

Minor reactions

- Reactions like Transfusion found from the unsure reactogenicity in opposition to the blood product used like plasma, serum and

total blood, e.g., A transient promoting into the temperature of the body by using 0.5-1.5°C 30 to one hundred twenty minutes after the serum transfusion. No severe destructive consequences were located in a CP trial for Ebola disorder in the yr 2015, this was once discovered in ninety-nine patients. In 9% the minor damaging effects have been detected, often itching and fever (5%) or cutaneous rash (4%) [55]. The accelerated detrimental results can also be seen in severely unwell instances if the transfusion is too fast.

- Shortly after transfusion Hyperpyrexia
- Generalized jaundice and Phlebitis

Serious to adequate transfusion-related detrimental events

- Response to serum ingredients, presuppose immunological reactions, e.g., serum sickness.
- Anaphylaxis
- Every other Transmission of the infectious ailment agent
- When CP remedy ingested into instances with pulmonary involvement, plasma transfusion brings some threat for the improvement of TRALI [61].
- Transfusion-associated circulatory overload (TACO) in unique sufferers with cardio-respiratory sick patients, superior age and renal impairment [19].

It is no longer described to what degree CP may shrink the development of an anticipated immune response, in the patient when utilized for prevention.

CP Banking

CP is mainly used as a fresh product. Aliquots can be easily collected with modern PI kits. Banking at a temperature below -25°C, according to EDQM guidelines for ordinary plasma for clinical use [59]. Most administrative frameworks require that CP is followed pre-eminently as a blood segment separate from conventional plasma for clinical use. The last approval name should report that the giver has tested negative at PCR for the healing issue and extra microbiological tests. The description of the inactivation method should be there. A solitary pattern of freezing and defrosting significantly influences amount or capacity of immune globulins there is no proof.

Side Benefits From CP in COVID-19

The patients who having humoral immune deficiencies can get benefited from polyclonal antibodies contained in Convalescent Plasma, and patients with haemorrhagic diathesis can also get benefit from clotting factors. The plasma is also may contain antibodies against the other beta coronaviruses related to the common cold, they may have been showing the cross-reaction with SARS-CoV2 antigens in intravenous immunoglobulin (IVIg) synthesis [61]. After an illustration of that group 0 healthcare workers were getting infected in low numbers with SARS-CoV [62], a research group defined that anti-A blood group natural isoagglutinins prohibit the SARS-CoV entry into competent cells [63].

Conclusion

Developing an antibody from convalescent plasma therapies, for the COVID-19, straight away and very trustworthy life-saving strategy. This crucial condition, the efficacy of this therapy towards a viral agent be increased by way of assessing scientific studies. In this preliminary case successions of five judgmentally ill patients with COVID-19 and ARDS, CP administration of covering neutralizing antibody was monitored by improvement in the patients' clinical status. The limited sample size and study design preclude a definitive statement about the potential effectiveness of this treatment, and these observations require evaluation in clinical trials. For more CP, blood facilities must start amassing plasma from recovering donors. The COVID-19- contaminated sufferers in appointments to donating plasma after medical institution discharge Clinicians can promote them. The use of this remedy also ought to help trade the route of this pandemic if the consequences of large-scale randomized scientific trials demonstrate efficacy. The applicable dose and utility duration of CP therapy nonetheless require an extra investigation in the upcoming future.

References

1. Shen C, Wang Z, Zhao F, Yang Y (2020) Treatment of 5 Critically Ill Patients With COVID-19 With Convalescent Plasma. *JAMA* 323: 1582-89.
2. World Health Organization (WHO) (2020) Novel coronavirus (COVID-19) situation.
3. Wu Z, Mc Googan JM (2020) Characteristics of and important lessons from the coronavirus disease 2019 (COVID-19) outbreak in China: summary of a report of 72 314 cases from the Chinese Center for Disease Control and Prevention. *JAMA*.
4. Chen L, Xiong J, Bao L, Shi Y (2020) Convalescent plasma as a potential therapy for COVID-19. *Lancet Infect Dis* 20: 398-400.
5. Cheng Y, Wong R, Soo YO, WS Wong, CK Lee, et al. (2005) Use of convalescent plasma therapy in SARS patients in Hong Kong. *Eur J Clin Microbiol Infect Dis* 24: 44-6.
6. Lai ST (2005) Treatment of severe acute respiratory syndrome. *Eur J Clin Microbiol Infect Dis* 24: 583-91.
7. Casadevall A, Pirofski LA (2020) The convalescent sera option for containing COVID-19. *J Clin Invest* 130: 1545-8.
8. Casadevall A, Scharff MD (1995) Return to the past: the case for antibody-based therapies in infectious diseases. *Clin Infect Dis* 21:150-61.
9. Casadevall A, Dadachova E, Pirofski LA (2004) Passive antibody therapy for infectious diseases. *Nat Rev Microbiol* 2: 695-703.
10. US Food and Drug Administration (FDA) (2020) Recommendations for Investigational COVID-19 Convalescent Plasma.

11. WHO Mers-Cov Research Group (2013) State of Knowledge and Data Gaps of Middle East Respiratory Syndrome Coronavirus (MERS-CoV) in Humans. *PLoS Curr*.
12. Ozdemir O, Melek Arsoy HE (2020) Convalescent (Immune) Plasma Therapy with all Aspects: Yesterday, Today and COVID-19. *Erciyes Med J* 42: 00-00.
13. Luke TC, Kilbane EM, Jackson JL, Hoffman SL (2006) Meta-analysis: convalescent blood products for Spanish influenza pneumonia: a future H5N1 treatment. *Ann Intern Med* 145: 599-609.
14. Gallagher JR (1935) Use of Convalescent Measles Serum to Control Measles in a Preparatory School. *Am J Public Health Nations Health* 25: 595-8.
15. Rambar AC (1946) Mumps; use of convalescent serum in the treatment and prophylaxis of orchitis. *Am J Dis Child* 71: 1-13.
16. Sahr F, Ansumana R, Massaquoi TA, Idriss BR, Sesay FR, et al. (2017) Evaluation of convalescent whole blood for treating Ebola Virus Disease in Freetown, Sierra Leone. *J Infect* 74: 302-9.
17. Hung IF, To KK, Lee CK, Lee KL, Chan K, et al. (2011) Convalescent plasma treatment reduced mortality in patients with severe pandemic influenza A (H1N1) 2009 virus infection. *Clin Infect Dis* 52: 447-56.
18. Zhang JS, Chen JT, Liu YX, Zhang ZS, Gao H, et al. (2005) A serological survey on neutralizing antibody titer of SARS convalescent sera. *J Med Virol* 77: 147-50.
19. Bloch EM, Shoham S, Casadevall A, Sachais BS, Shaz B, et al. (2020) Deployment of convalescent plasma for the prevention and treatment of COVID-19. *J Clin Invest* 130: 2757-65.
20. Yeh KM, Chiueh TS, Siu LK, Lin JC, Chan PK, et al. (2005) Experience of using convalescent plasma for severe acute respiratory syndrome among healthcare workers in a Taiwan hospital. *J Antimicrob Chemother* 56: 919-22.
21. Wong VW, Dai D, Wu AK, Sung JJ (2003) Treatment of severe acute respiratory syndrome with convalescent plasma. *Hong Kong Med J* 9: 199-201.
22. Kong L (2003) Severe acute respiratory syndrome (SARS). *Transfus Apher Sci* 29: 101.
23. Ko JH, Müller MA, Seok H, Park GE, Lee JY, et al. (2017) Serologic responses of 42 MERS-coronavirus-infected patients according to the disease severity. *Diagn Microbiol Infect Dis* 89: 106-11.
24. Arabi YM, Hajeer AH, Luke T, Raviprakash K, Balkhy H, et al. (2016) Feasibility of Using Convalescent Plasma Immunotherapy for MERS-CoV Infection, Saudi Arabia. *Emerg Infect Dis* 22: 1554-61.
25. Chun S, Chung CR, Ha YE, Han TH, Ki CS, et al. (2016) Possible Transfusion-Related Acute Lung Injury Following Convalescent Plasma Transfusion in a Patient With Middle East Respiratory Syndrome. *Ann Lab Med* 36: 393-5.
26. Huaxia (2020) China puts 245 COVID-19 patients on convalescent plasma therapy. News release, Xinhua Net.
27. Daniele F, Arthur A, Julian T, Marco T (2020) Convalescent Plasma Therapy for COVID-19.
28. Commission E (2020) Guidance on collection, testing, processing, storage, distribution and monitored use Brussels.
29. El-Ekiaby M, Sayed MA, Caron C, Burnouf S, El-Sharkawy N, et al. (2010) Solvent-detergent filtered (S/D-F) fresh frozen plasma and cryoprecipitate minipools prepared in a newly designed integral disposable processing bag system. *Transfusion Med* 20: 48-61.
30. Eickmann M, Gravemann U, Handke W, Tolksdorf F, Reichenberg S, et al. (2018) Inactivation of Ebola virus and Middle East respiratory syndrome coronavirus in platelet concentrates and plasma by ultraviolet C light and methylene blue plus visible light, respectively. *Transfusion* 58: 2202-7.
31. Xu D, Zhang Z, Jin L, Chu F, Mao Y, et al. (2005) Persistent shedding of viable SARS-CoV in urine and stool of SARS patients during the convalescent phase. *Eur J Clin Microbiol Infect Dis* 24: 165-71.
32. Liu W, Fontanet A, Zhang PH, Zhan L, Xin ZT, et al. (2006) Two-year prospective study of the humoral immune response of patients with severe acute respiratory syndrome. *J Infect Dis* 193: 792-5.
33. Wu LP, Wang NC, Chang YH, Tian XY, Na DY, et al. (2007) Duration of antibody responses after severe acute respiratory syndrome. *Emerging infectious diseases* 13: 1562-4.
34. Mair-Jenkins J, Saavedra-Campos M, Baillie JK, Cleary P, Khaw FM, et al. (2015) The effectiveness of convalescent plasma and hyperimmune immunoglobulin for the treatment of severe acute respiratory infections of viral etiology: a systematic review and exploratory meta-analysis. *J Infect Dis* 211: 80-90.
35. Hang Z, Xie YW, Hong J, Zhang X, Kwok SY, et al. (2005) Purification of severe acute respiratory syndrome hyperimmune globulins for intravenous injection from convalescent plasma. *Transfusion* 45: 1160-4.
36. Soo YO, Cheng Y, Wong R, Hui DS, Lee CK, et al. (2004) Retrospective comparison of convalescent plasma with continuing high-dose methylprednisolone treatment in SARS patients. *Clin Microbiol Infect* 10: 676-8.
37. Chun S, Chung CR, Ha YE, Han TH, Ki CS, et al. (2016) Possible Transfusion-Related Acute Lung Injury Following Convalescent Plasma Transfusion in a Patient with Middle East Respiratory Syndrome. *Ann Lab Med* 36: 393-5.
38. Arabi Y, Balkhy H, Hajeer AH, Bouchama A, Hayden FG, et al. (2015) Feasibility, safety, clinical, and laboratory effects of convalescent plasma therapy for patients with Middle East respiratory syndrome coronavirus infection: a study protocol. *Springerplus* 4:709.
39. Choe PG, Perera R, Park WB, Song KH, Bang JH, et al. (2017) MERS-CoV Antibody Responses 1 Year after Symptom Onset, South Korea, 2015. *Emerg Infect Dis* 23: 1079-84.
40. Ko JH, Seok H, Cho SY, Ha YE, Baek JY, et al. (2018) Challenges of convalescent plasma infusion therapy in Middle East respiratory coronavirus infection: a single centre experience. *Antivir Ther* 23: 617-22.
41. Zhu N, Zhang D, Wang W, Li X, Yang B, et al. (2020) A Novel Coronavirus from Patients with Pneumonia in China, 2019. *N Engl J Med* 382: 727-33.
42. Zhou F, Yu T, Du R, Fan G (2020) Clinical course and risk factors for mortality of adult inpatients with COVID-19 in Wuhan, China: a retrospective cohort study. *Lancet* 395: 1054-62.
43. Casadevall A, Pirofski L (2020) The convalescent sera option for containing COVID-19. *J Clin Invest* 130: 1545-8.
44. Chen L, Xiong J, Bao L, Shi Y (2020) Convalescent plasma as a potential therapy for COVID-19. *Lancet Inf Dis* 20: 398-400.
45. Chen X, Zhao B, Qu Y, Chen Y, Xiong J, et al. (2020) Detectable serum SARS-CoV-2 viral load (RNAemia) is closely associated with drastically elevated interleukin 6 (IL-6) level in critically ill COVID-19 patients. *Clin Infect Dis*.
46. Guo L, Ren L, Yang S, Xiao M, Chang D, et al. (2020) Profiling Early Humoral Response to Diagnose Novel Coronavirus Disease (COVID-19). *Clin Infect Dis*.
47. Zhao J, Yuan Q, Wang H, Liu W, Liao X, et al. (2020) Antibody responses to SARS-CoV-2 in patients of novel coronavirus disease 2019. *Clin Infect Dis*.

48. Long Q, Deng H, Chen J, Hu J, Liu B, et al. (2020) Antibody responses to SARS-CoV-2 in COVID-19 patients: the perspective application of serological tests in clinical practice. *Med Rxiv*.
49. Zeng F, Dai C, Cai P, Wang J, Xu L, et al. (2020) A comparison study of SARS-CoV-2 IgG antibody between male and female COVID-19 patients: a possible reason underlying different outcome between genders. *Med Rxiv* pp. 1-5.
50. Chan KH, Cheng VC, Woo PC, Lau SK, Poon LL, et al. (2005) Serological responses in patients with severe acute respiratory syndrome coronavirus infection and cross-reactivity with human coronaviruses 229E, OC43, and NL63. *Clin Diagn Lab Immunol* 12: 1317-21.
51. Cao WC, Liu W, Zhang PH, Zhang F, Richardus JH (2007) Disappearance of antibodies to SARS-associated coronavirus after recovery. *N Engl J Med* 357: 1162-3.
52. Casadevall A, Scharff MD (1994) Serum therapy revisited: animal models of infection and development of passive antibody therapy. *Antimicrob Agents Chemother* 38: 1695-702.
53. Ko JH, Müller MA, Seok H, Park GE, Lee JY, et al. (2017) Serologic responses of 42 MERS-coronavirus-infected patients according to the disease severity. *Diagn Microbiol Infect Dis* 89: 106-11.
54. Ko JH, Seok H, Cho SY, Ha YE, Baek JY, et al. (2018) Challenges of convalescent plasma infusion therapy in Middle East respiratory coronavirus infection: a single centre experience. *Antivir Ther* 23: 617-22.
55. Cheng Y, Wong R, Soo YO, Wong WS, Lee CK, et al. (2005) Use of convalescent plasma therapy in SARS patients in Hong Kong. *Eur J Clin Microbiol Infect Dis* 24: 44-6.
56. Zhang B, Liu S, Tan T, Huang W, Dong Y, et al. (2020) Treatment with convalescent plasma for critically ill patients with SARSCoV-2 infection. *Chest* S0012-3692: 30571-7.
57. Tiberghien P, de Lambalerie X, Morel P, Gallian P, Lacombe K, et al. (2020) Collecting and evaluating convalescent plasma for COVID-19 treatment: why and how. *Vox Sang* pp. 1-7.
58. Duan K, Liu B, Li C, Zhang H, Yu T, Qu J, et al. (2020) The feasibility of convalescent plasma therapy in severe COVID-19 patients: a pilot study pp. 1-22.
59. The Mayo Clinic IRB (2020) Expanded Access to Convalescent Plasma for the Treatment of Patients with COVID-19.
60. Wu F, Wang A, Liu M, Wang Q, Chen J, et al. (2020) Neutralizing antibody responses to SARS-CoV-2 in a COVID-19 recovered patient cohort and their implication.
61. Diez JM, Romero C, Gajardo R (2020) Currently available intravenous immunoglobulin (Gamunex®-C and Flebogamma® DIF) contains antibodies reacting against SARS-CoV-2 antigens. *bioRxiv*.
62. Gajic O, Rana R, Winters JL, Yilmaz M, Mendez JL, et al. (2007) Transfusion-related acute lung injury in the critically ill: prospective nested case-control study. *Am J Respir Crit Care Med* 176: 886-91.
63. Guillon P, Clément M, Sébille V, Rivain J-G, Chou C-F, et al. (2008) Inhibition of the interaction between the SARS-CoV Spike protein and its cellular receptor by antihisto-blood group antibodies. *Glycobiology* 18: 1085-93.