

Ethnobiology drug development for COVID-19 and future pandemics

ARTIVEDA™/ OT-101/ COVID-19

DEC 1, 2020

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Building the next generation biotech focusing on speed and efficiency





Yes, we need a vaccine to control Covid-19. But we need new treatments, too By Karen Mulligan and Karen Van Nuys/August 5, 2020 and John Whyte, MD, MPH; Davey Smith, MD/October 06, 2020

A vaccine is not a silver bullet

 Even if proven safe and effective, vaccines are difficult to make and distribute. Treatments are an essential part of the Covid-19 fight for two reasons.

 First, they are an indispensable tool for managing the pandemic before a vaccine is available. And second, even after a vaccine is available, treatments will be the essential backstop to manage illness resulting from imperfections in vaccine effectiveness and uptake.

An economic model from USC Schaeffer Center

 A treatment that can cut the need for hospitalization by 50% would result in 285,000 fewer admissions for Covid-19 and up to 71,000 fewer deaths by the end of 2021, assuming that 20% of the population becomes infected and half of those with symptoms get the treatment.

Economic Offset Model

 An effective treatment would also offset the economic losses. Given the \$7.9 trillion negative impact Covid-19 has had on the U.S. economy, if a treatment could offset the economic losses by even 5% (or almost \$400 billion), the economic benefit would be 5X-7X larger than the health benefits in the model.

https://www.statnews.com/2020/08/05/we-need-a-covid-19-vaccine-but-we-need-new-treatments-too/



And the virus will keep mutating





Fourth state confirms mink farm coronavirus outbreaks as U.S. looks to avoid Denmark's disaster. Oregon had become the fourth state to confirm a coronavirus outbreak on a domestic mink farm.

Danish minks were culled en masse weeks earlier after scientists discovered they carried a mutated strain of the virus that if spread back to humans could reduce the efficacy of a potential vaccine.

Conventional COVID-19 Response Programs



Trillions of dollars/ Countless manhours without a therapeutic in sight

Time to revamp the conventional approach



Conventional COVID-19 Therapeutics

Drug Name	Mechanism/ Target	Outcome	Trial Name/N
Lopinavir	Antiviral/ Protease Inhibitor	Fail	WHO SOLIDARITY/ 1411 UK RECOVERY/ 1616
Hydroxychloroquine	Antiviral/ Antimalarial/ TRL	Fail	WHO SOLIDARITY/ 954 UK RECOVERY/ 790
Remdesivir	Antiviral/ RNA Polymerase	Fail	WHO SOLIDARITY/ 2750
Interferon	Antiviral/Immune Activation	Fail	WHO SOLIDARITY/ 2063
Kevzara [®] (sarilumab)	mAb against IL-6 receptor	Fail	Sanofi Phase 3/ 420 Total
Actemra (tocilizumab)	mAb against IL-6 receptor	Fail	COVACTA/ 450 Total
laris [®] (canakinumab)	mAb against IL-1β	Fail	CAN-COVID/ 454 Total
Bamlanivimab/ LY-CoV555	anti-SARS-CoV-2 mAb (Spike Protein)	Fail	BLAZE-2/350 Total
Convalescent plasma	Anti-SARS-CoV-2 antibodies	Fail	India PLACID/ 464 Total
Dexamethasone	Anti-Inflammatory	<u>Success</u>	RECOVERY/ 2104

Large WHO SOLIDARITY Trial and UK RECOVERY Trial – only DEXAMETHASONE was effective – but only for severe COVID



Plus and Minus with conventional pathway

- Highly bureaucratic and Expensive infrastructure
 - IRB Approval/ Regulatory Approval /Import permit
 - Logistics/ Site training/ Pts Recruitment
 - Solidarity Trial- Example of a rapid reponse trial: 11 Feb/ Concept => 6 Mar/ Protocol => 18 Mar/ Launch => 17 Jun HCQ failed => 15 Nov/ Interim Read/ Remdesivir failed
- Strength in the data to conclusively prove whether the drug is working or not
- Singular focus on one drug for one disease
- > The further down the road the more unlikely the drug can be repositioned for novel infectious agent
- Most important- regulatory authorities do make mistakes ie. Remdesivir
- Everyone was chasing the wrong targets





TGF-β Positive Feedback Loop

- SAR-CoV-2 infection upregulates TGF-β and Furin.
 Stukalov A et al. bioRxiv.2020.06.17.156455
- > TGF- β locks cell cycle allowing the virus to replicate.
- TGF-β drives the expression of Furin- a protease required for the cellular entry of SARS-CoV-2. In well-differentiated primary human 1 bronchial epithelial cells, TGF-β1 and TGF-β2 induce expression of furin. Michael J. O'Sullivan, Jennifer A. Mitchel, Chimwemwe Mwase, Maureen McGill, Phyllis Kanki, Jin-Ah Park
- Furin /SARS-CoV-2/ TGF-β constitutes the positive loop that keeps spinning off TGF-β resulting in TGF-β surge
- Nothing is more dangerous than a out of control positive feedback loop





Impacts of TGF-β Surge



\succ TGF- β recruits neutrophils into the site of

inflammation laying down neutrophil extracellular traps (NET's) responsible for capillaritis, fibrin deposition, mucositis in COVID-19 [Barnes BJ et al. J Exp Med. 2020;217(6):e20200652.].

- TGF-β inhibits ENaC and causes fluid accumulation in the lung and ARDS/pneumonia. [Pittet JF et al. J Clin Invest. 2001;107(12):1537-1544.].
- TGF-β induces late stage fibrosis compromising
 lung capacity even after recovery [Wang L et al. Int J Clin Exp Pathol.
 2019;12(7):2604-2612. Published 2019 Jul 1].
- TGF-β induces IL-6 leading to systemic inflammation and "cytokine storm". [Turner M et al. Cytokine. 1990;2(3):211-216.].
- \succ TGF- β induces TGFBIp leading to vascular

inflammation. Park et al. found that TGFBIp and its derivative TGFBIp K676Ac, acetylated 676th lysine TGFBIp, are elevated in the blood of SARS-CoV-2 pneumonia patients (n=113); especially in intensive care unit (ICU)

patients than non-ICU patients [Park HH et al. Sci. Adv. 2020; DOI: 10.1126/sciadv.abc1564.].

TGF-β induces IgA class switching leading to IgA vasculitis/ Kawasaki Disease syndrome. A significant positive association was found between SARS-CoV-2 specific IgA level and the APACHE II score in critically ill patients with COVID 19 (r=0.72, P=0.01) [Yu HQ et al. Eur Respir J. 2020;2001526.].





COVID-19 Clinical Trials- Hypercompetitive

- ➢ 3,807 studies on ClinicalTrial.gov
- > 753 studies on CTRI- India clinical trial registry
- > US COVID 19
 - Highly competitive environment.
 - Low infection rate => too many trials competing
 - High infection rate => too busy treating patients
- Ex-US COVID-19
 - > Less competitive.
 - > Need to pair up with a strong local CRO
 - Logistics/Importing issues
 - Central lab issues
- Australia
 - Few infection => shut down in hot spots
- ➢ UK- COVID-19
 - UK Recovery trial



A Double-Blind, Randomized, Placebo-Controlled, Multi-Center Study of OT-101 in COVID-19 Subjects



27 Oct 2020-----First patient in expect Dec 15 and top line data 1Q21

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C001 Leads



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COVID-19 CLINICAL COURSE AFTER SARS-COV-2 INFECTION AND THE OT-101 TRIAL



COVANCE.

UCKUN FM, TRIEU V. ANNA PUL AND CRI CAR MED..2020; 3(1); 01-09.

- The in vitro antiviral activity against SARS-CoV-2 (USA_WA1/2020 strain) was tested in Vero 76 cells in collaboration with Dr. Brett Hurst at Utah State University that is part of the NIAID Antiviral Testing Consortium.
- OT-101- an antisense against TGF- β was effective against both SARS-CoV and SARS-CoV-2.
- After our disclosure in April 2020, other investigators have come forward with similar results
- Wei J. et al. Preprint. bioRxiv. 2020;2020.06.16.155101. SIS3, an inhibitor of SMAD3 of the TGF-β pathway, exhibited dose dependent protection from virus-induced cell death and also inhibited SARS-CoV-2 replication
- Stukalov A et al. bioRxiv.2020.06.17.156455. Upon virus infection, there was an upregulation of TGF-β and EGFR pathways.







TGF-β Surge in COVID-19

- Elevated TGF-β2 expression among RNAs isolated from the bronchoalveolar lavage (BAL) fluid of COVID-19 patients versus normal controls has been reported [Xiong Y et al. Emerg Microbes Infect. 2020;9(1):761-770].
- TGF-β is higher among severe COVID-19 patients. Normal TGF-β level is 4000 pg/ml. The TGF-β level in COVID-19 patients is in 10,000 and above [Agrati C et al. Cell Death Differ. 2020;1-12.]
- Levels of systemic TGF-β in serum from healthy individuals (n=7) and COVID-19 patients with mild (n=12), moderate (n=7) and severe (n=7) disease using LEGENDplex assay [Mann ER et al. Sci. Immunol. 2020. 10.1126/sciimmunol.eabd6197].
- COVID-19 induces a chronic, TGF-β-dominated adaptive immune response [Ferreira-Gomes M et al. medRxiv. 2020. doi:https://doi.org/ 10.1101/2020.09.04.20188169]



Objectives

Primary	
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Evaluate the safety and efficacy of OT-101 when used in combination with SoC: *Efficacy: Proportion of subjects with clinical improvement score (measured by an 8 point WHO COVID 19 Clinical Improvement Ordinal Scale) at Day 14 Safety: Adverse events, clinical labs, ECG, vital signs, physical exam, radiology tests*



Further evaluate the efficacy of OT-101 compared to placebo: Odds ratio, ventilator requirements, clinical improvement / worsening, mortality, hospitalization (duration/ICU)

Exploratory

Assessment of inflammatory biomarkers Assessment of viral dynamics

CUVA

Study Design

Randomized, double-blind, placebo-controlled study to evaluate the efficacy, safety, and tolerability of OT-101 when used in combination with SoC in hospitalized subjects with mild or severe COVID-19.

Sites and Subject Population

- Approximately 6 sites in Peru and Argentina.
- Adult subjects with mild (Part 1) or severe (Part 2) COVID-19 with a positive PCR test within the last 1 week for Part 1 and 2 weeks for Part 2 prior to randomization.
- Approximately 36 to 72 subjects are planned to be enrolled.

Double-blind Treatment and Assessment Period

- > 3-day screening period.
- Randomization and treatment to start on Day 1 to either receive OT-101 or placebo in a 2:1 ratio for 7 days in combination with SoC therapy per local SoC policies, followed to Day 28.





Ethnobiology COVID-19 Response Program



- Masks
- Social Distancing
- Hand Washing
- Dexamethasone
- ArtiShield[™]/ARTIV eda[™]/ Artemisinin



Plus and Minus with Ayurvedic pathway

- Manufacturing- Marked variations are observed amongst the same formulations manufactured by different companies and by the same company. This raises questions on the quality standards.
 - Nearly 21% of commercially available formulations contained detectable levels of lead, mercury, and arsenic.
- Clinical trial- Often difficult to perform as per strict Ayurvedic principle. Almost all are without control arm making interpretation difficult if not impossible.
- Strength in eons of coevolution and millennia of ethnobiology. Holistic focus. Broad clinical activities. Can be positioned for novel infectious agent
- > Need to strengthen composition, manufacturing, and clinical testing.
- > Ayurvedic text needs updating.

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Artemisinin vs. Artemisinins

- Ayurveda- Broad Activity/ Low Specificity
- Appropriate for rapid response to pandemic \succ



- Allopathic- Narrow Activity/ High Specificity
- Appropriate for safe and effective drugs

Arteether





Artemisinin Dihydroartemisinin

Artesunate





Artemether

SM905





SM934

Malaria



Financial Cost – Artemisinin versus Remdesivir

The ideal therapies should be inexpensive and prophylactic and should be able to be administered to:
 1) non-hospitalized persons at the time of their initial diagnosis.
 2) individuals with appearance of potential symptoms.
 3) healthy individuals exposed to the virus





Allopathic drug cost = **Remdesivir = \$2,000**/ **Ayurvedic drug = ArtiVeda™ = \$10**/ **Vaccine = \$20**

Ayurveda - Dvipaantara Damanaka

- ➤ ArtiVedaTM is the Ayurveda Dvipaantara Damanaka- and is labeled as capsule containing Artemisia Powder 500mg.
- Its approved use is per Ayurvedic text: fever and inflammation. Ayurveda is part of the principal medicinal system in India for centuries.
- The application of Ayurvedic agent to treat the symptoms of COVID-19 such as fever, headache, and inflammation is appropriate.
- Dvipaantara Damanaka is the pharmacopoeial name equated with Artemisia absinthium Linn./ A. nilagirica (Clarke) Pam., syn./ A. vulgaris Linn. Var. nilagarica Clarke. [2,3]
- Artemesia nilagarica and Artermesia vulgaris are found throughout the hilly regions of India, ascending to an altitude of 3600 m in the Western Himalayas and to 1500-2400 m in Sikkim and Khasi hills.
- [2] C. Khare, Evidence-based Ayurveda.Defining a new scientific path, Routledge, 2020.
- [3] C. P. Khare, Ayurvedic Pharmacopoeial Plant Drugs: Expanded Therapeutics, CRC Press, 2016.





In Silico Activities against SARS-CoV2

- Molecular basis for drug repurposing to study the interface of the S protein in SARS-CoV-2 and human ACE2 through docking, characterization, and molecular dynamics for natural drug candidates. Meshari Alazmi & Olaa Motwalli
- ZINC natural library with a total of ~ 203,458 drug molecules were screened in silico through blind docking against the S protein: human ACE2 complex.
- Four drugs— Andrographolide, Artemisinin, Pterostilbene, and Resveratrol—were selected on the basis of multiple criteria such as binding score, hydrophobic, electrostatic, and pi-pi cationic interactions with the protein.



Doczking Pose for Artemisinin docked with human ACE2: S protein complex in the interface between both proteins. (Right) Ligand interaction diagram showing important interactions involved in the complex.



Artemisinin/ TGF-β Inhibitor/ In Vitro Antiviral Activity

- ➤ Artemisinin is an active component of ArtiVedaTM.
- Artemisinin is able to inhibit <u>human</u> TGF-β and is able to neutralize SARS-CoV-2 (COVID-19) in vitro at an EC50 of 0.45 ug/ml (based on Mateon's test result at Utah State University), and a Safety Index of 140, which is better than remdesivir and chloroquine.
- The unpurified herb extract has no anti-viral activity.
- As a TGF-β inhibitor it should target multiple viral threats including COVID-19 by suppressing both viral replication and clinical symptoms that arise from viral infection.
- > TGF- β is an ancient master regulator in both human and plant



In vitro efficacy of Artemisinin-based treatments against SARS-CoV-2

Kerry Gilmore, Yuyong Zhou, Santseharay Ramirez, Long V. Pham, Ulrik Fahnøe, Shan Feng, Anna Offersgaard, Jakob Trimpert, Jens Bukh, Klaus Osterrieder, Judith M. Gottwein, Peter H. Seeberger doi: https://doi.org/10.1101/2020.10.05.326637

This article is a preprint and has not been certified by peer review [what does this mean?].



"SAFETY AND EFFICACY OF ARTEMISININ-PIPERAQUINE (AP) FOR TREATMENT OF COVID-19" INT J ANTIMICROBIAL AGENTS. 2020 NOV 2

- **<u>Two groups</u>**: artemisinin-piperaquine (AP) group (n=23) and control group (n=18).
- **Primary outcome:** time taken to reach undetectable levels of severe acute respiratory syndromecoronavirus-2 (SARS-CoV-2) and the percentage of participants with undetectable SARS-CoV-2 on day 7, 10, 14, and 28.
- <u>Control group</u>: Hydroxychloroquine/Arbidol. Hydroxychloroquine sulfate (Shanghai Zhongxi Pharmaceutical Co., Ltd.) was orally administered as a loading dose of 800mg/day for the first three days, followed by a maintenance dose of 400mg daily for the next five days. Arbidol hydrochloride (CSPC Ouyi Pharmaceutical Co., Ltd.) was orally administrated 600 mg/day for eight days, divided into three doses daily.
- <u>AP group</u>: AP (ARTEPHARM Co., Ltd) was orally administrated with a loading dose of two tablets (artemisinin 125mg and piperaquine 750mg) for the first day and followed by a maintenance dose of one tablet/day (artemisinin 62.5mg and piperaquine 375mg) for the next six days. The total dose was eight tablets in 7 days.



"SAFETY AND EFFICACY OF ARTEMISININ-PIPERAQUINE (AP) FOR TREATMENT OF COVID-19" INT J ANTIMICROBIAL AGENTS. 2020 NOV 2

- Piperaquine and hydroxychloroquine are members of the quinoline family and they both have marginal activity against SARS-CoV-2 *in vitro only. HCQ failed clinical trials against COVID-19.* Therefore Artemisinin is the main difference between the two arms
- Time to Undetectable SARS-CoV-2 RNA in the AP group was significantly less than the control group (AP: 10.6±1.1 days), Control: 19.3±2.1 days). P value is highly significant (p=0.001).
- Length of hospital stay for AP group was 13.3±4.8 days, and Control was 21.3±9.1 days

	Table 3		
	The time of patients to undetectable vira	1 RNA	
		AP (N=23)	Control (N=18)
Time	to undetectable viral RNA of days(Mean±SD)	10.6±1.1	19.3±2.1
	Patients with undetectable viral RNA, N(%)		
	Day 7	6(26.1)	1(5.6)
	Day 10	10(43.5)	3(16.7)
	Day 14	18(78.3)	8(44.4)
	Day 21	23(100.0) 10(55.6)
	Day 28	23(100.0) 13(72.2)
	Duration of hospitalization (Days, Mean±SD)	13.3±4.8	21.3±9.1

AP: Artemisinin + Quinoline (Piperaquine), Control: Quinoline (Hydroxychloroquine or HCQ)



WE CAN STOP THE PANDEMIC WITH 50% REDUCTION IN DAYS BEING INFECTIOUS



Current Clinical Program for Artemisinin/ArtiVeda ARTI-19



A PROSPECTIVE, RANDOMIZED, MULTI-CENTER, OPEN LABEL, INTERVENTIONAL STUDY TO EVALUATE THE SAFETY AND EFFICACY OF DAMANAKA 500 MG CAPSULE IN TREATMENT OF ADULT SUBJECTS WITH COVID-19

Global trial with 3 sites open in India:

- Maharashtra
- Andhra Pradesh
- Utter Pradesh

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- Number of Subjects: 120
- Expanding to 300 subjects at 6 sites

Arms opening in:

- Nigeria
- Peru





ARTI-19 CLINICAL TRIAL IN INDIA

- Open label, 2nd Arm control, multi-center Phase IV study
 - Compares the efficacy of ORAL doses with standard-ofcare (SOC) versus SOC alone.
 - SOC is per Clinical Management Protocol
 - Moderate cases (WHO scale 4-5), patients skewed towards moderate
- 2:1 randomization (Damanaka capsules + SOC vs SOC)
 - Patients in study arm take 5 pills in 5 days: 1 pill per day.
 - If symptoms remain a second cycle follows after 5-day rest period
 - Duration for subject: 28 days





EFFICACY IN ARTI-19 INDIA

- At present: 78 pts randomized into ARTI-19
 - Dec 15th: Complete randomization of 120 pts/ Interim Report for 60 pts/ EUA application.
 - Beyond Dec 15th: Expansion to 6 sites and 300 pts/Global expansion 3000 pts
- Observations for current completed data set on 32 pts. Only WHO Scale 4 pts are shown here.
 - 8 pts on SOC and 16 pts on ARTIVeda[™]+SOC
 - SOC: No Treatment time dependent effect.
 - ARTIVedaTM+ SOC: Treatment time dependent improvement in WHO Progression Scale.
 - Majority of pts on ArtiVeda[™] achieved reduction from WHO Progression Scale of 4 to WHO Progression Scale of 3 on Day 2 (2nd dosing with ARTIVeda[™]).





Scale of 3 does not have to be hospitalized

Conclusions

- Artemisinin activity against COVID-19 is well supported at all levels: in silico, in vitro, and clinical
- It is the only potentially prophylactic agent and cost-effective agent
- Such an agent is needed to stop the pandemic even in the presence of an effective vaccine
- It is active at all phases of COVID-19 infection
- It will be launch in India by year end
- OT-101 soon after as EUA against severe COVID-19

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Thank You

