FLUIDIGM®

Mass Cytometry in COVID-19 Research

As of August 16, 2021

Publications, Preprints and Clinical Research Trials

Mass cytometry, powered by CyTOF® technology, is being used in dozens of labs around the world as well as several large consortia to understand the immune response to COVID-19 infection and provide critical information needed for the development and design of therapies and vaccines. The following is a current list of publications and clinical research trials where mass cytometry or Imaging Mass Cytometry™ (IMC™) has been utilized.

Publications

2021

1 Adam, L. et al. "Nucleocapsid-specific and PD-L1+CXCR3+ CD8 polyfunctional T-cell abundances are associated with survival of critical SARS-CoV2-infected patients." *JCI Insights* (2021): doi:10.1172/jci.insight.151571.

2 Adamo, S. et al. "Profound dysregulation of T cell homeostasis and function in patients with severe COVID-19." *Allergy* (2021) doi:10.1111/all.14866.

3 Barone, S.M. et al. "Unsupervised machine learning reveals key immune cell subsets in COVID-19, rhinovirus infection, and cancer therapy." *eLife* 10 (2021): doi:10:e64653.

4 Basar, R. et al. "Generation of glucocorticoid resistant SARS-CoV-2 T-cells for adoptive cell therapy." *Cell Reports* 36 (2021): 109432.

5 Bergamaschi, L. et al. "Delayed bystander CD8 T cell activation, early immune pathology and persistent dysregulation characterise severe COVID-19." *Immunity* 54 (2021): 1257–1275.E8.

6 Bolouri, H. et al. "The COVID-19 immune landscape is dynamically and reversibly correlated with disease severity." *Journal of Clinical Investigation* 131 (2021): e143648.

7 Bongiovanni, D. et al. "SARS-CoV-2 infection is associated with a pro-thrombotic platelet phenotype." *Cell Death & Disease* 12 (2021): 50.

8 De Biasi, S. et al. "Endogenous control of inflammation characterizes pregnant women with asymptomatic or paucisymptomatic SARS-CoV-2 infection." *Nature Communications* 12 (2021): 4677.

9 De Cevins, D. et al. "A monocyte/dendritic cell molecular signature of SARS-CoV2-related multisystem inflammatory syndrome in children (MIS-C) with severe myocarditis." *Med* (2021): doi:10.1016/j.medj.2021.08.002.

10 Galbraith, M.D. et al. "Seroconversion stages COVID19 into distinct pathophysiological states." *eLife* 10 (2021): e65508.

11 Geanon, D. et al. "A streamlined whole blood CyTOF® workflow defines a circulating immune cell signature of COVID-19." *Cytometry Part A* 99 (2021): 446–461.

12 Hao, Y. et al. "Integrated analysis of multimodal single-cell data." *Cell* 184 (2021): 3,573–3,587.

13 Kared, H. et al. "SARS-CoV-2-specific CD8+ T cell responses in convalescent COVID-19 individuals." *Journal of Clinical Investigation* 131 (2021): e145476.

14 Klug, M. et al. "Platelet surface protein expression and reactivity upon TRAP stimulation after BNT162b2 vaccination." *Thrombosis and Haematosis* (2021): doi:10.1055/s-0041-1733934.

15 Ma, T. et al. "Protracted yet coordinated differentiation of long-lived SARS-CoV-2-specific CD8+ T cells during COVID-19 convalescence." *The Journal of Immunology* (2021): ji2100465.

16 Mitamura, Y. et al. "Cutaneous and systemic hyperinflammation drives maculopapular drug exanthema in severely ill COVID-19 patients." *Allergy* (2021): doi:10.1111/all.14983.*

17 Morrissey, S. et al. "A specific low-density neutrophil population correlates with hypercoagulation and disease severity in hospitalized COVID-19 patients." *JCI Insight* 6 (2021): e148435.

18 Penttilä, P.A. et al. "High dimensional profiling identifies specific immune types along the recovery trajectories of critically ill COVID19 patients." *Cellular and Molecular Life Sciences* (2021): 1–16.

19 Rendeiro, A.F. et al. "The spatial landscape of lung pathology during COVID-19 progression." *Nature* 593 (2021): 564–569.

20 Rouphael, N. et al. "Immunophenotyping assessment in a COVID-19 cohort (IMPACC): A prospective longitudinal study" *Science Immunology* 6 (2021): eabf3733.

21 Roussel, M. et al. "Mass cytometry and artificial intelligence define CD169 as a specific marker of SARS-CoV2-induced acute respiratory distress syndrome." *Cell Reports Medicine* (2021): ssrn.3751801.

22 Schulien, I. et al. "Characterization of pre-existing and induced SARS-CoV-2-specific CD8+ T cells." *Nature Medicine* 27 (2021): 78–85.

23 Schwabenland, M. et al. "Deep spatial profiling of COVID-19 brains reveals neuroinflammation by compartmentalized local immune cell interactions and targets for intervention." *Cell* 54 (2021): 1,594–1,610.e11.*

24 Sciacchitano, S. et al. "Gene signature and immune cell profiling by high-dimensional, single-cell analysis in COVID-19 patients, presenting Low T3 syndrome and coexistent hematological malignancies." *Journal of Translational Medicine* 19 (2021): 139.

25 Sullivan, K.D. et al. "The COVIDome explorer researcher portal." *Cell Reports* 36 (2021): 109527.

26 Tang, X. et al. "Early use of corticosteroid may prolong SARS-CoV-2 shedding in non-intensive care unit patients with COVID-19 pneumonia: A multicenter, single-blind, randomized control trial." *Respiration* 100 (2021): 116–126.

27 Unal, M.A. et al. "2D MXenes with antiviral and immunomodulatory properties: A pilot study against SARS-CoV-2." *Nano Today* 38 (2021): 101136.

28 Vanderbeke, L. et al. "Monocyte-driven atypical cytokine storm and aberrant neutrophil activation as key mediators of COVID-19 disease severity." *Nature Communications* 12 (2021): 4117.

29 Wilk, A.J. et al. "Multi-omic profiling reveals widespread dysregulation of innate immunity and hematopoiesis in COVID-19." *Journal of Experimental Medicine* 218 (2021): e20210582.

*Publications citing use of IMC

30 Yeo, J.G. et al. “A virus-specific immune rheostat in the immunome of patients recovering from mild COVID-19.” *Frontiers in Immunology* 12 (2021): 674279.

31 Yu, H.B. et al. “Immune responses and pathogenesis in persistently PCR-positive patients with SARS-CoV-2 infection.” *Journal of Medical Virology* 93 (2021): 760–765.

2020

1 Arunachalam, P.S. et al. “Systems biological assessment of immunity to mild versus severe COVID-19 infection in humans.” *Science* 369 (2020): 1,210–1,220.

2 Chevrier, S. et al. “A distinct innate immune signature marks progression from mild to severe COVID-19.” *Cell Reports Medicine* 2 (2020): 100166.

3 Goshen-Lago, T. et al. “The potential role of immune alteration in the cancer-COVID19 equation—a prospective longitudinal study.” *Cancers* 12 (2020): E2421.

4 Gruber, C. et al. “Mapping systemic inflammation and antibody responses in multisystem inflammatory syndrome in children (MIS-C).” *Cell* 183 (2020): 982–995.e14.

5 Guerin, C.L. et al. “Multidimensional proteomic approach of endothelial progenitors demonstrate expression of KDR restricted to CD19 cells.” *Stem Cell Reviews and Reports* (2020): 1–13.

6 Hadjadj, J. et al. “Impaired type I interferon activity and inflammatory responses in severe COVID-19 patients.” *Science* 369 (2020): 718–724.

7 Leng, Z. et al. “Transplantation of ACE2– mesenchymal stem cells improves the outcome of patients with COVID-19 pneumonia.” *Aging and Disease* 11 (2020): 216–228.

8 Neidleman, J. et al. “SARS-CoV-2-specific T cells exhibit unique features characterized by robust helper function, lack of terminal differentiation, and high proliferative potential.” *Cell Reports Medicine* 1 (2020): 100081.

9 Ouyang, Y. et al. “Down-regulated gene expression spectrum and immune responses changed during the disease progression in COVID-19 patients.” *Clinical Infectious Diseases* 71 (2020): 2,052–2,060.

10 Rodriguez, L. et al. “Systems-level immunomonitoring from acute to recovery phase of severe COVID-19.” *Cell Reports Medicine* 1 (2020): 100078.

11 Schulte-Schrepping, J. et al. “Severe COVID-19 is marked by a dysregulated myeloid cell compartment.” *Cell* 182 (2020): 1419–1440.e23.

12 Shi, H. et al. “The inhibition of IL-2/IL-2R gives rise to CD8+ cell and lymphocyte decrease through JAK1-STAT5 in critical patients with COVID-19 pneumonia.” *Cell Death & Disease* 11 (2020): 429.

13 Shi, W. et al. “High-dimensional single-cell analysis reveals the immune characteristics of COVID-19.” *American Journal of Physiology Lung Cellular and Molecular Physiology* 320 (2020): L84–L98.

14 Silvin, A. et al. “Elevated calprotectin and abnormal myeloid cell subsets discriminate severe from mild COVID-19.” *Cell* 182 (2020): 1401–1418.e18.

15 Wang, C. et al. “Imaging Mass Cytometric analysis of postmortem tissues reveals dysregulated immune cell and cytokine responses in multiple organs of COVID-19 patients.” *Frontiers in Microbiology* 11 (2020): 600989.*

16 Wang, W. et al. “High-dimensional immune profiling by mass cytometry revealed immunosuppression and dysfunction of immunity in COVID-19 patients.” *Cellular & Molecular Immunology* 17 (2020): 650–652.

*Publications citing use of IMC

17 Wei, L. et al. “Dysregulation of the immune response affects the outcome of critical COVID-19 patients.” *Journal of Medical Virology* 92 (2020): 2,768–2,776.

18 Zhang, Y. et al. “Inflammatory response cells during acute respiratory distress syndrome in patients with coronavirus disease 2019 (COVID-19).” *Annals of Internal Medicine* 11 (2020): 402–404.*

19 Zheng, Y. et al. “A human circulating immune cell landscape in aging and COVID-19.” *Protein & Cell* 11 (2020): 740–770.

Preprints

1 Aleman, A. et al. “Fatal breakthrough infection after anti-BCMA CAR-T therapy highlights suboptimal immune response to SARS-CoV-2 vaccination in myeloma patients.” *medRxiv* (2021): doi.org/10.1101/2021.05.15.21256814.

2 Carapito, R. et al. “Identification of driver genes for severe forms of COVID-19 in a deeply phenotyped young patient cohort.” *medRxiv* (2021): doi.org/10.1101/2021.06.21.21257822.

3 Feyaerts, D. et al. “Integrated plasma proteomic and single-cell immune signaling network signatures demarcate mild, moderate, and severe COVID-19.” *bioRxiv* (2021): doi.org/10.1101/2021.02.09.430269.

4 Galbraith, M.D. et al. “Specialized interferon ligand action in COVID19.” *medRxiv* (2021): doi.org/10.1101/2021.07.29.21261325.

5 Kramer, K.J. et al. “Single-cell profiling of the antigen-specific response to BNT162b2 SARS-CoV-2 RNA Vaccine.” *bioRxiv* (2021): doi.org/10.1101/2021.07.28.453981.

6 Lim, J. et al. “Data-driven analysis of COVID-19 reveals specific severity patterns distinct from the temporal immune response.” *bioRxiv* (2021): doi.org/10.1101/2021.02.10.430668.

7 Livanos, A.E. et al. “Gastrointestinal involvement attenuates COVID-19 severity and mortality.” *medRxiv* (2020): doi.org/10.1101/2020.09.07.20187666.

8 Neidleman, J. et al. mRNA vaccine-induced T cells respond identically to SARS-CoV-2 variants of concern but differ in longevity and homing properties depending on prior infection status.” *bioRxiv* (2021): doi.org/10.1101/2021.05.12.443888.

9 Padgett, L.E. et al. “Interplay of monocytes and T lymphocytes in COVID-19 severity.” *bioRxiv* (2020): doi.org/10.1101/2020.07.17.209304.

10 Roukens, A.H.E. et al. “Prolonged activation of nasal immune cell populations and development of tissue-resident SARS-CoV-2 specific CD8 T cell responses following COVID-19.” *medRxiv* (2021): doi.org/10.1101/2021.04.19.21255727.

11 Syrimi, E. et al. “The innate and adaptive immune landscape of SARS-CoV-2-associated Multisystem Inflammatory Syndrome in Children (MIS-C) from acute disease to recovery.” *iScience* (2021): doi.org/10.2139/ssrn.3828199.

12 Turnbull, I.R. et al. “Dysregulation of the leukocyte signaling landscape during acute COVID-19.” *Research Square* (2021): doi:10.21203/rs.3.rs-244150/v1.

*Publications citing use of IMC

Clinical Research Trials

1. Immunophenotyping Assessment in a COVID-19 Cohort (IMPACC) (NCT04378777)
   Sponsor: National Institute of Allergy and Infectious Disease (NIAID); 12 participating institutions in North America

2. In-Depth Immunological Investigation of COVID-19. (COntAGIouS) (NCT04327570)
   Sponsor: Universitaire Ziekenhuizen Leuven

3. Prospective Natural History Study of Smoking, Immune Cell Profiles, Epigenetics and COVID-19 (NCT04403386)
   Sponsor: National Institute of Environmental Health Sciences (NIEHS)

4. Mesenchymal Stem Cell for Acute Respiratory Distress Syndrome Due for COVID-19 (COVID-19) (NCT04416139)
   Sponsor: Instituto Nacional de Ciencias Medicas y Nutricion Salvador Zubiran

5. Systematic Assessment of SARS-CoV-2 Neurotropic Capacity in Modestly and Critically Ill Patients, and Patients Who Died From COVID-19 (NCT04472013)
   Sponsor: University Hospital, Basel, Switzerland

6. Efficacy and Safety of Corticosteroids in COVID-19 (NCT04273321)
   Sponsor: Beijing Chao Yang Hospital

7. COVID-19: Pediatric Research Immune Network on SARS-CoV-2 and MIS-C (PRISM) (NCT04588363)
   Sponsor: National Institute of Allergy and Infectious Diseases (NIAID)

8. COVID-19 Longitudinal Biomarkers in Lung Injury (COLOBILI) (NCT04747782)
   Sponsor: Dr. Andrew Baker, Unity Health Toronto

9. Severe Acute Respiratory Syndrome Corona Virus 2 (SARS-CoV-2) Immune Kidney Transplant Study (COVID-19) (SCV-KTx-imm) (NCT04747522)
   Sponsor: Oslo University Hospital

10. Immunogenecity and Safety of VaccinemRNA-1273 in Elderly Volunteers (Over 65 y) Compared to Younger Ones (18-45y) (CoviCompareM) (NCT04748471)
    Sponsor: Assistance Publique – Hôpitaux de Paris

11. COVID-19, Aging, and Cardiometabolic Risk Factors Study (CARAMEL) (NCT04802044)
    Sponsor: Indonesia University

12. BNT162b2 Vaccination With Two Doses in COVID-19 Negative Adult Volunteers and With a Single Dose in COVID-19 Positive Adult Volunteers (CoviCompareP) (NCT04824638)
    Sponsor: ANRS, Emerging Infectious Diseases

Learn more about the use of mass cytometry and IMC in COVID-19 research at: **fluidigm.com/covidresearch** | **fluidigm.com/covidvaccinedev**

Download the entire Mass Cytometry Bibliography at: **fluidigm.com/cytofpubs**

CORPORATE HEADQUARTERS
2 Tower Place, Suite 2000
South San Francisco, CA 94080 USA
Toll-free: 866 359 4354 in the US and Canada
Fax: 650 871 7152
fluidigm.com

SALES
North America | +1 650 266 6170 | info-us@fluidigm.com
Europe/EMEA | +33 1 60 92 42 40 | info-europe@fluidigm.com
Latin America | +1 650 266 6170 | info-latinamerica@fluidigm.com
Japan | +81 3 3662 2150 | info-japan@fluidigm.com
China (excluding Hong Kong) | +86 21 3255 8368 | info-china@fluidigm.com
All other Asian countries | +1 650 266 6170 | info-asia@fluidigm.com