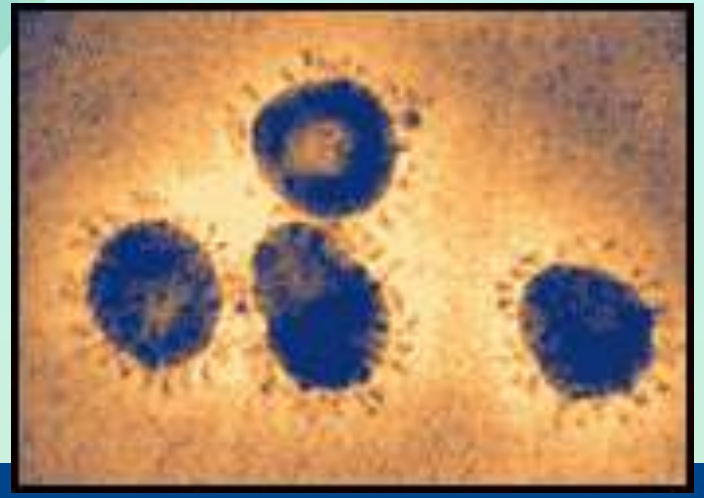
Infection Control in Dialysis Facilities in the Age of Coronavirus



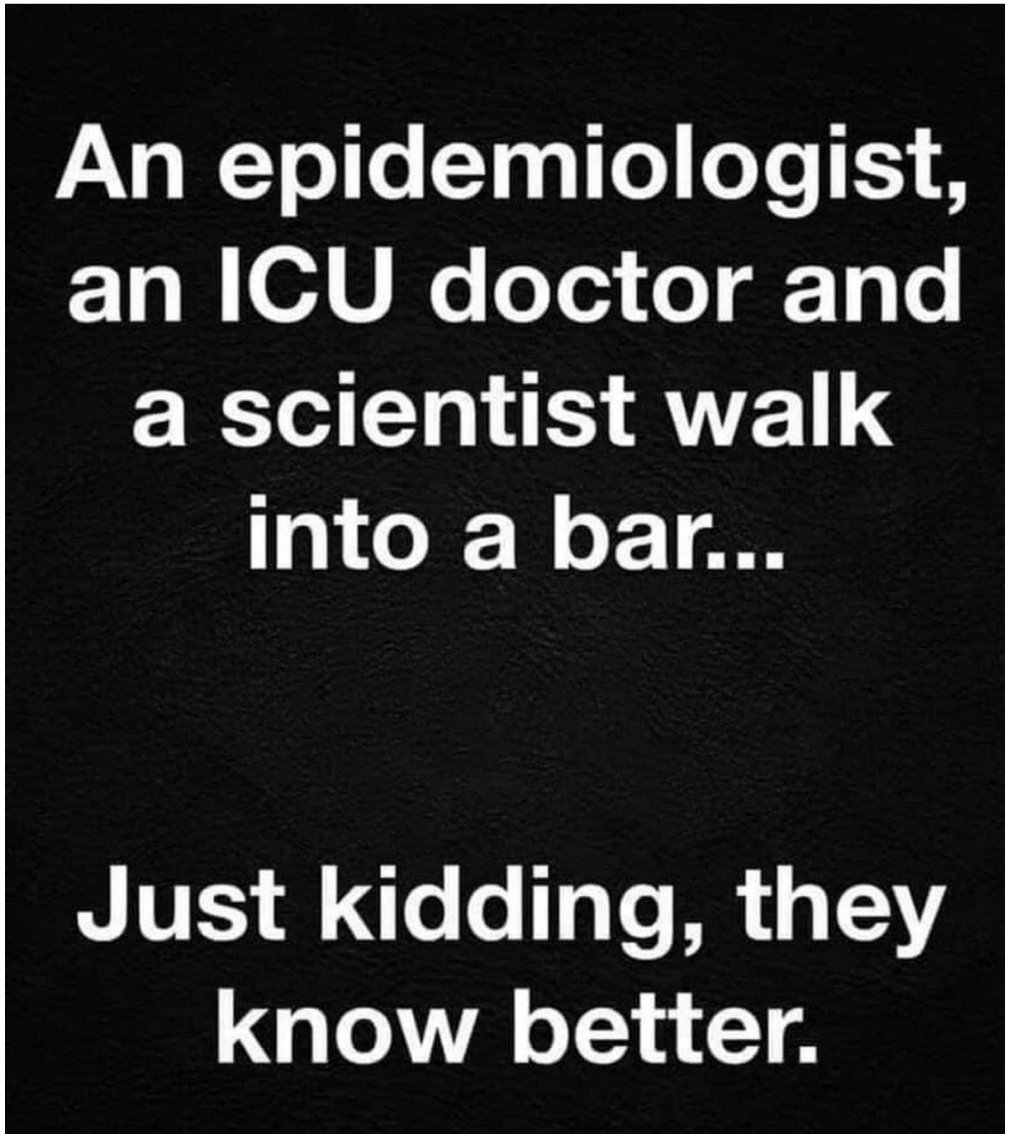
Alan S. Kliger, MD
April 2021

NTDS
Transforming Dialysis Safety

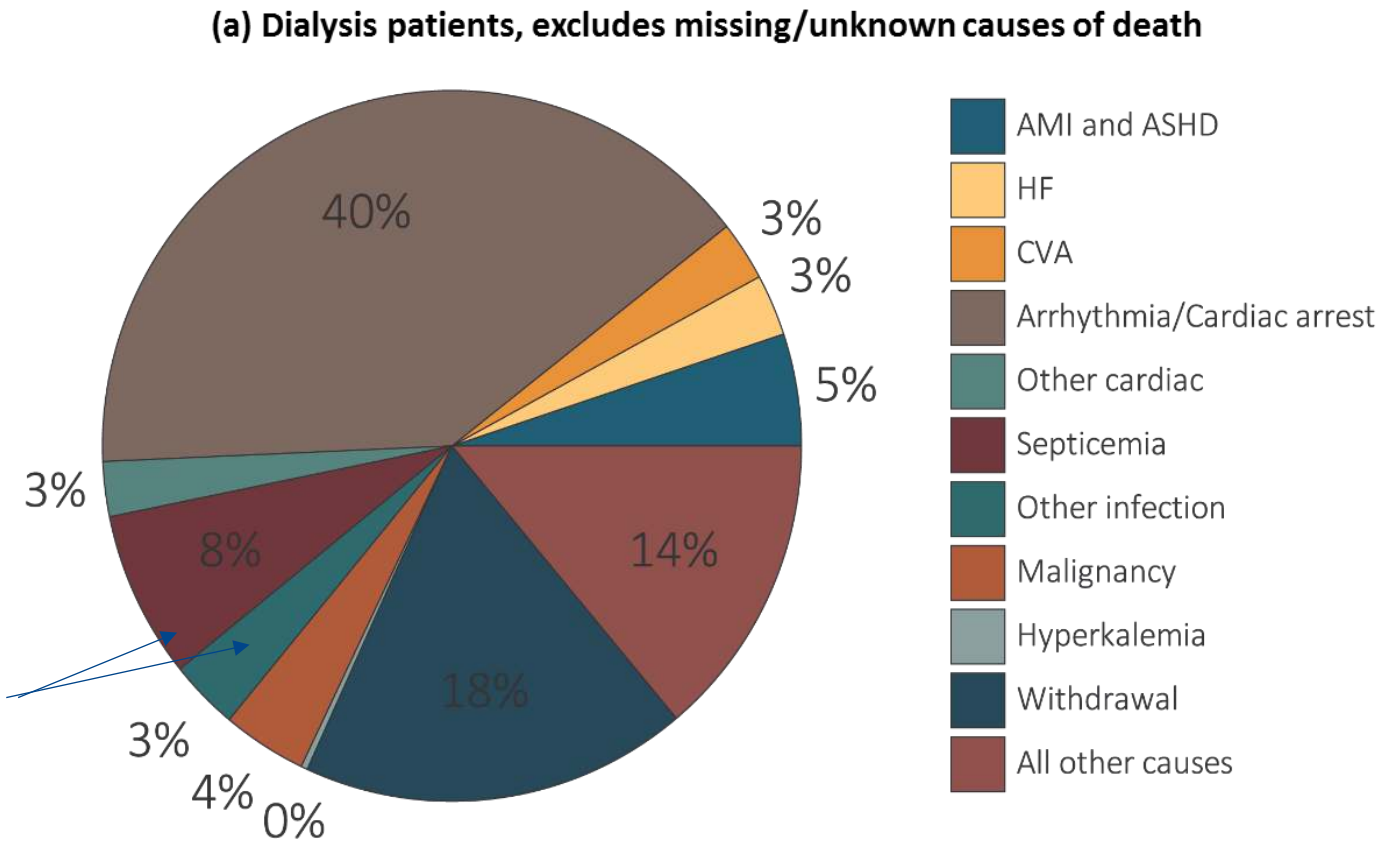
ALAN S. KLIGER, MD

NTDS Project Chair; COVID-19 Response Team Co-Chair
Yale School of Medicine

- **Consultancy Agreements:** ASN; National Institutes of Diabetes, Digestive Diseases and the Kidney
- **Honoraria:** several universities and medical schools, professional organizations - honoraria for lectures, seminars, webinars;
- **Scientific Advisor or Membership:** Qualidigm (Quality Improvement Organization);
- **Other Interests/Relationships:** Renal Physicians Association; American Society of Nephrology


An epidemiologist, an ICU doctor and a scientist walk into a bar...
Just kidding, they know better.

vol 2 Figure 5.4 Unadjusted percentages of deaths in 2015 by cause, with and without missing data, by modality among dialysis patients and transplant recipients

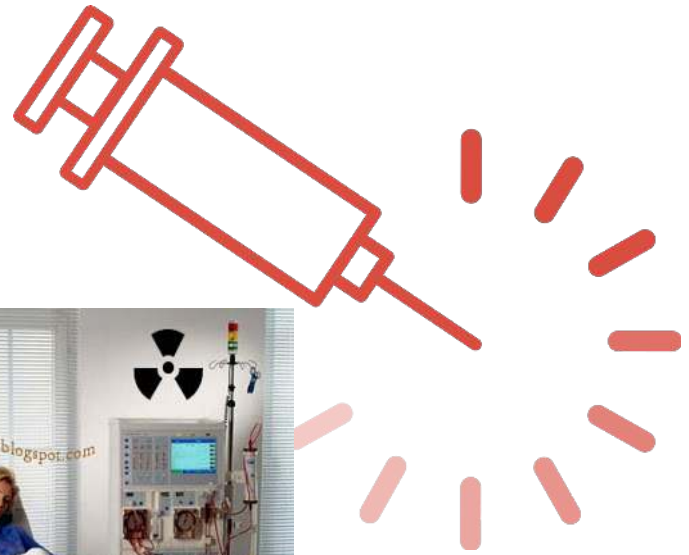


Infection

Data Source: Special analysis using Reference Table H.12_Dialysis and H.12_Tx. Mortality among 2015 prevalent patients. (a) Dialysis patients, denominator excludes missing/unknown causes of death. (b) Transplant recipients, denominator excludes missing/unknown causes of death. (c) Dialysis patients, denominator includes missing/unknown causes of death. (d) Transplant recipients, denominator includes missing/unknown causes of death. Abbreviations: AMI, acute myocardial infarction; ASHD, atherosclerotic heart disease; CHF, congestive heart failure; CVA, cerebrovascular accident.

CDC Studies: Major Risk Areas for Infection

- Hand Hygiene
- Catheter Use
- Injection Safety
- Station Disinfection



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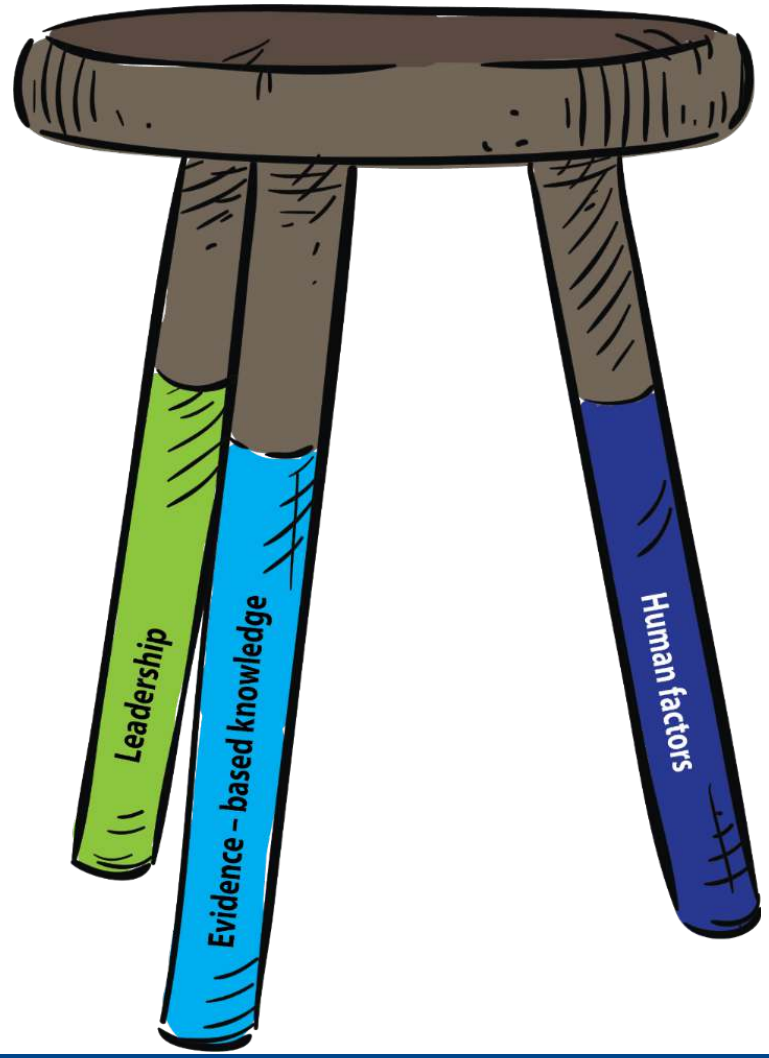
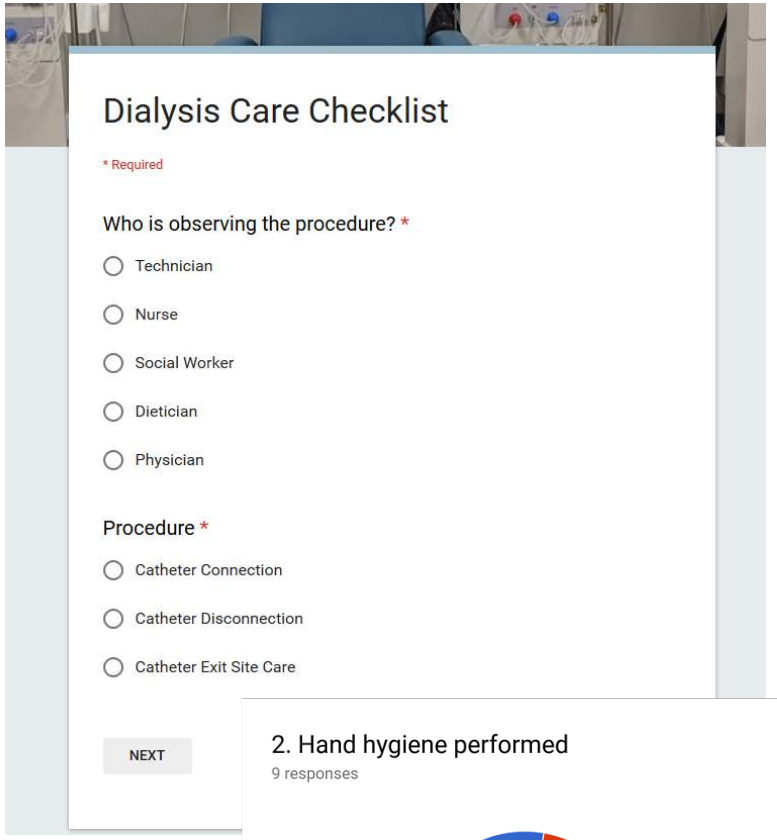
NTDS Dialysis Quality and Safety Platform

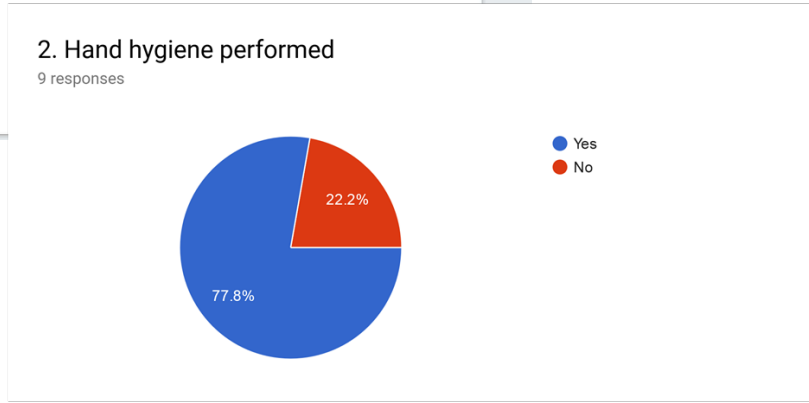
- **Identify, Develop, Share Evidence-Based Knowledge:**
  - Foster learning: staff and patients
  - Educational conferences & webinars
  - **www.asn-online.org/NTDS**
- **Improve System Function Using Human Factors Engineering**
  - Measure and improve the way care is delivered in dialysis facilities
- **Promote Effective Leadership**
  - Power of Inspirational Leadership
  - Commit to eliminate infections
  - Create psychological safety and empower others
  - Nephrologists must lead by example



Dialysis Care Checklist Pilot

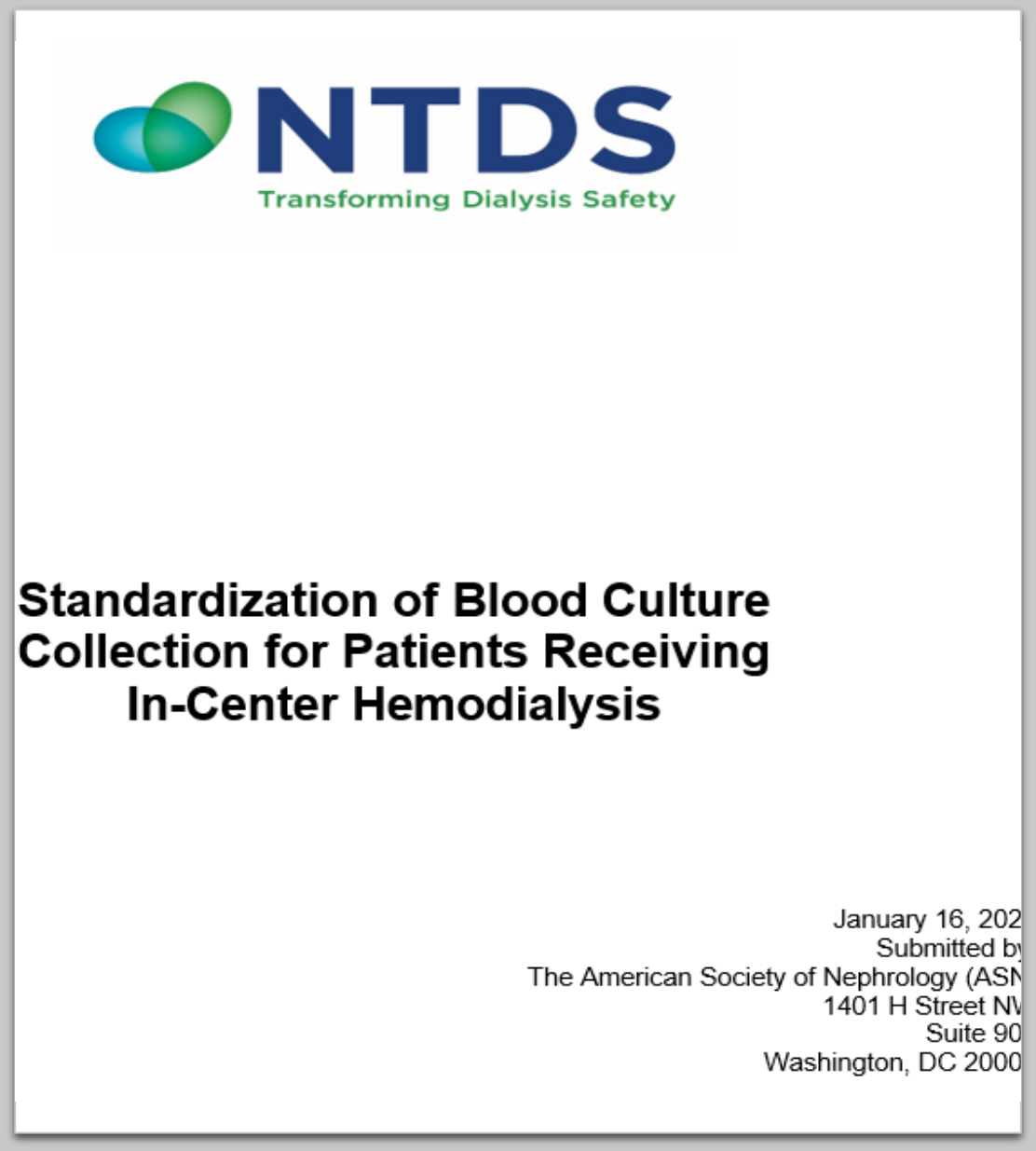
- Goal: Determine feasibility of increasing the use of CDC chairside checklists to improve infection control practices in outpatient dialysis.
- Pilot study results in preparation



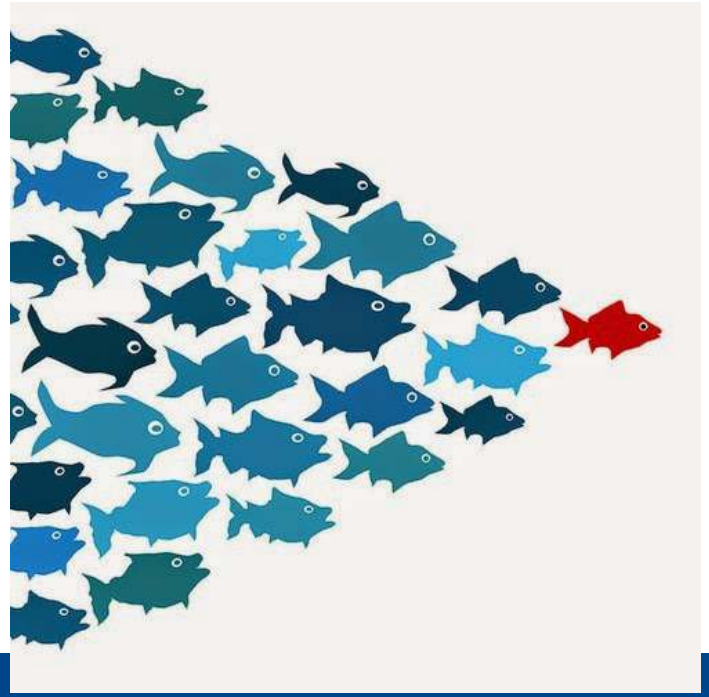


Blood Culture Standardization

- A set of standard Recommendations (12) and Rationale for each Recommendation based on the literature and guidance from professional organizations (CDC, IDSA, CLSI)
- Includes 2 sites from which blood can be accessed, including the catheter hub, the hemodialysis circuit (tubing connected to the catheter hub), and a peripheral vein
- SBAR introductory slide set and template
- A step-by-step blood culture draw procedure
- A competency checklist and recommendations
- https://www.asn-online.org/g/blast/files/NTDS_Blood_Culture_Collection_Standardization_combined_01.16.2020.pdf



Developing Effective Leadership and Culture in Dialysis



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Leadership, Education and Culture Change

- Kidney Leadership Academy (Pilot with NKC)
  - Agenda
    - Personality Types
    - Team Verses Group
    - Leading Your Way to Success: Five Key Leadership Lessons
    - Essence of Change: Effective Strategies for Change Management
    - Application of Effective Conflict Management for Physicians
    - Competing Stakeholders for Dialysis
  - Six-month Follow-up
  - Evaluation

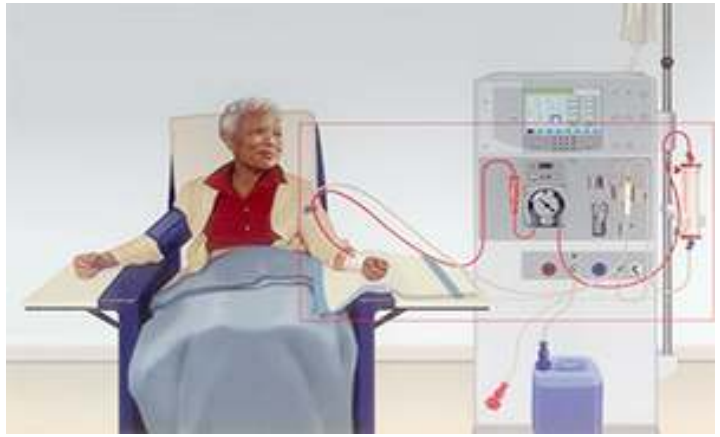
Human Factors Engineering

Human factors is a scientific discipline that examines human capabilities and limitations and applies that knowledge to the design of tools, technology, and processes to facilitate safe, efficient, and effective work.

The focus of human factors is to integrate the scientific findings from psychology and engineering on human performance and to apply those findings to the design of daily work.

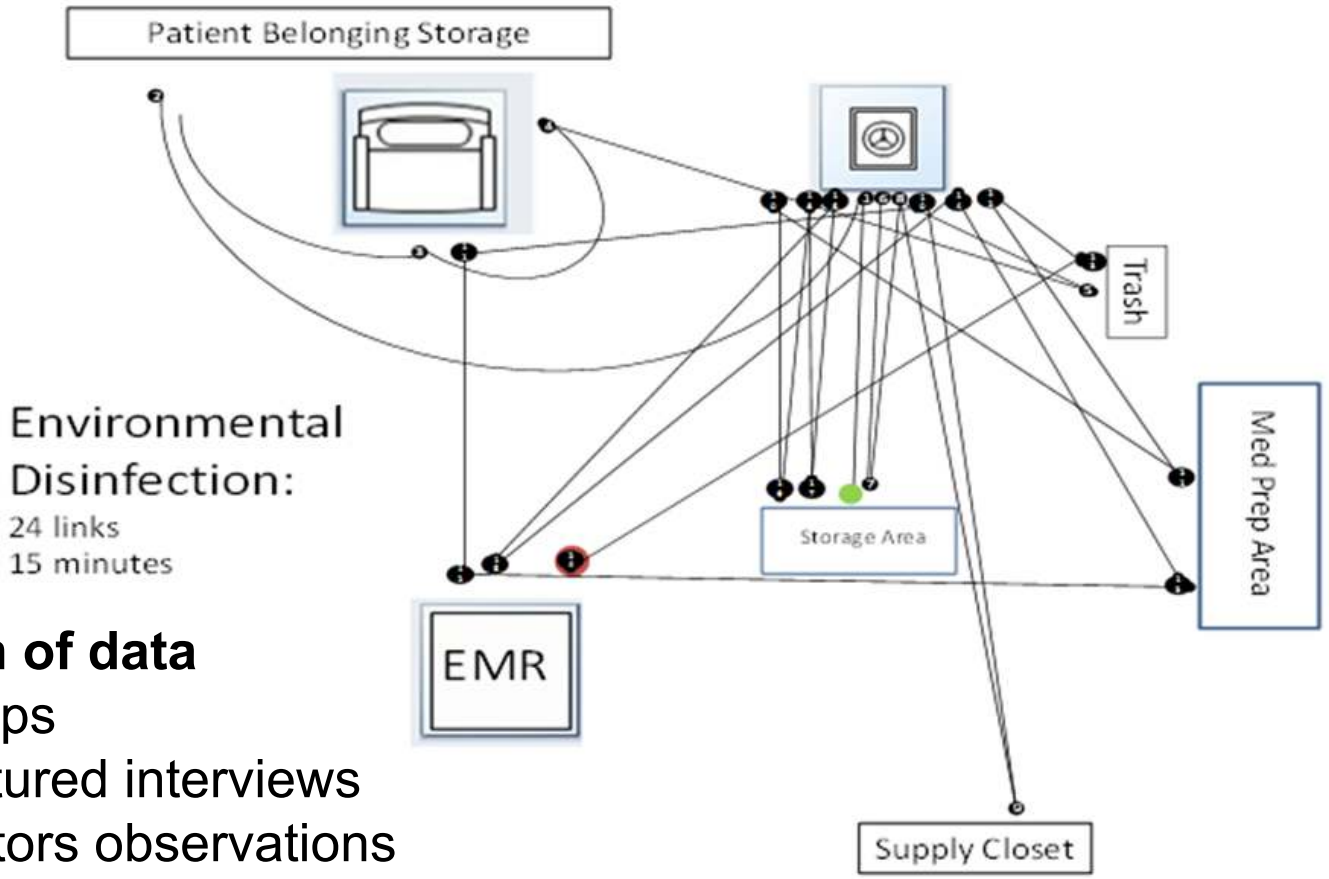
We can’t change the human condition, but we can change the conditions in which humans work

Work as Imagined



Work as performed

Human Factors Assessment: Methods



Link analysis created while observing disinfection of the dialysis station.

TimeCat used to capture and organize data

Triangulation of data

- Focus groups
- Semi-structured interviews
- Human factors observations
  - TimeCat
  - Link analyses
  - Ethnographic observations
- Infection Prevention observations

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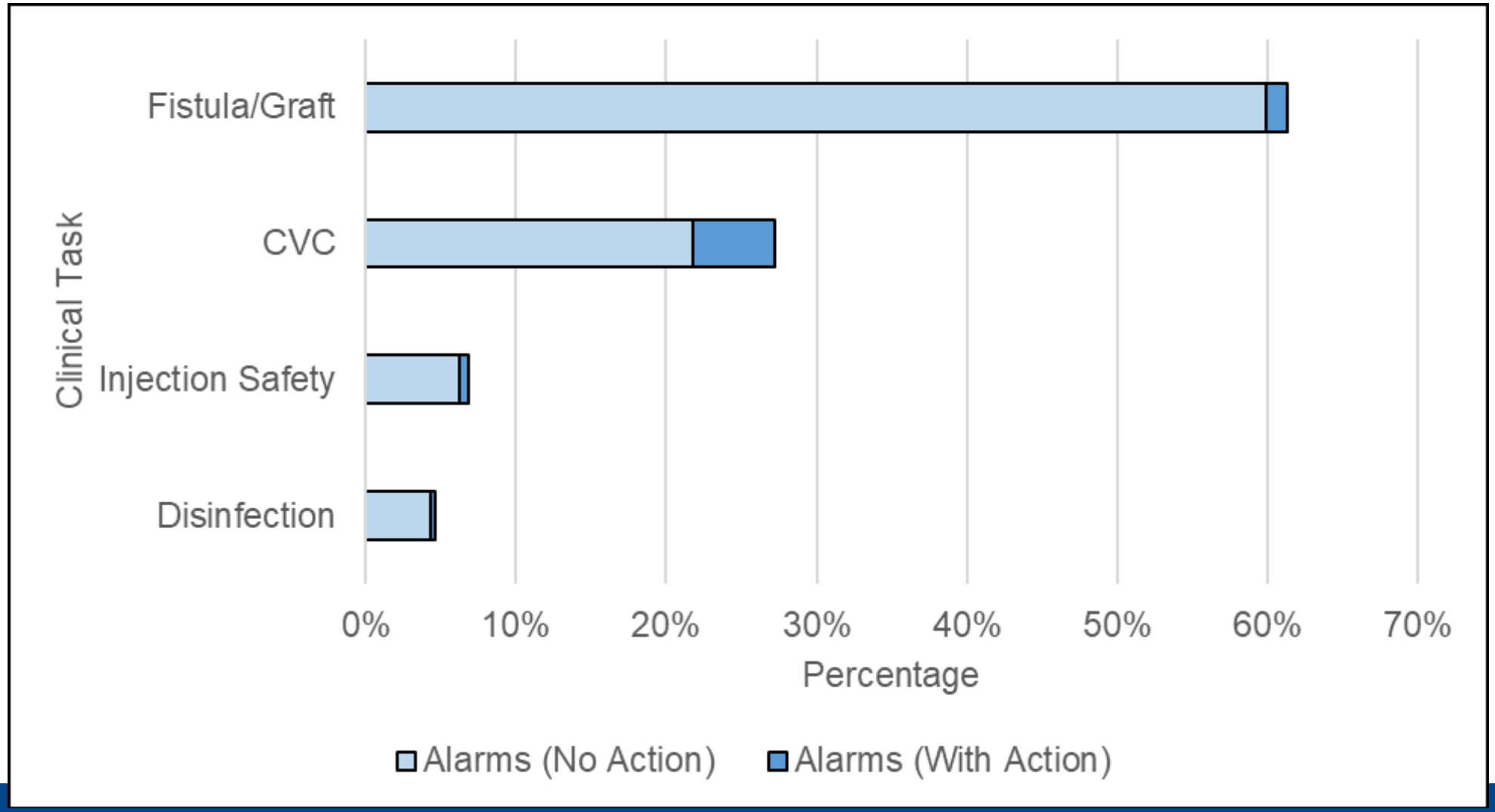
Alarms During Critical Tasks



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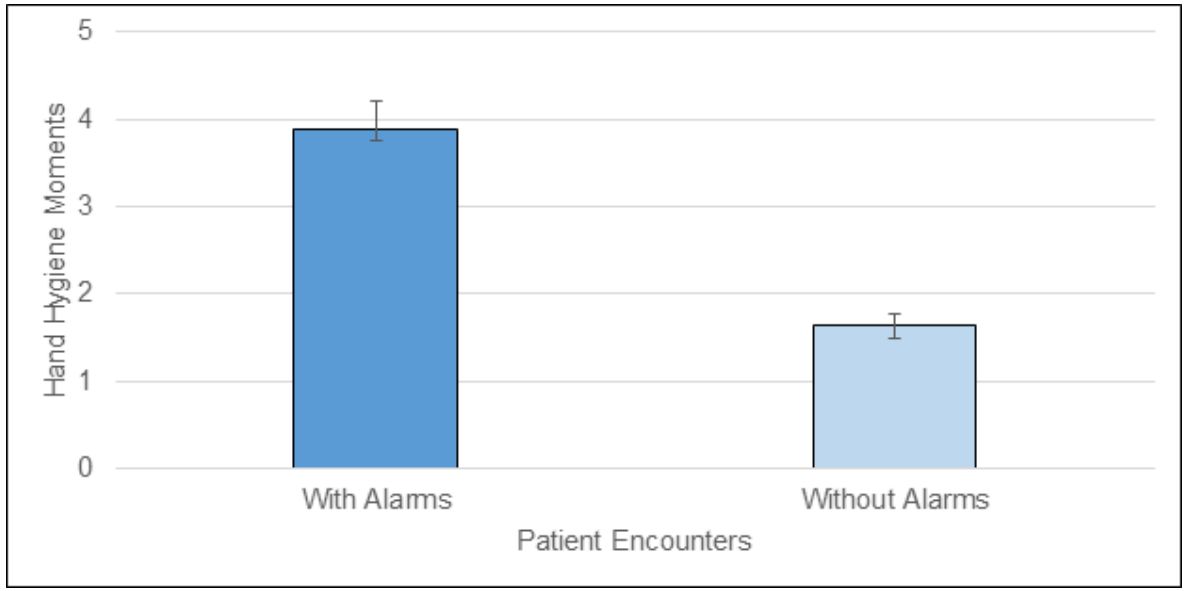
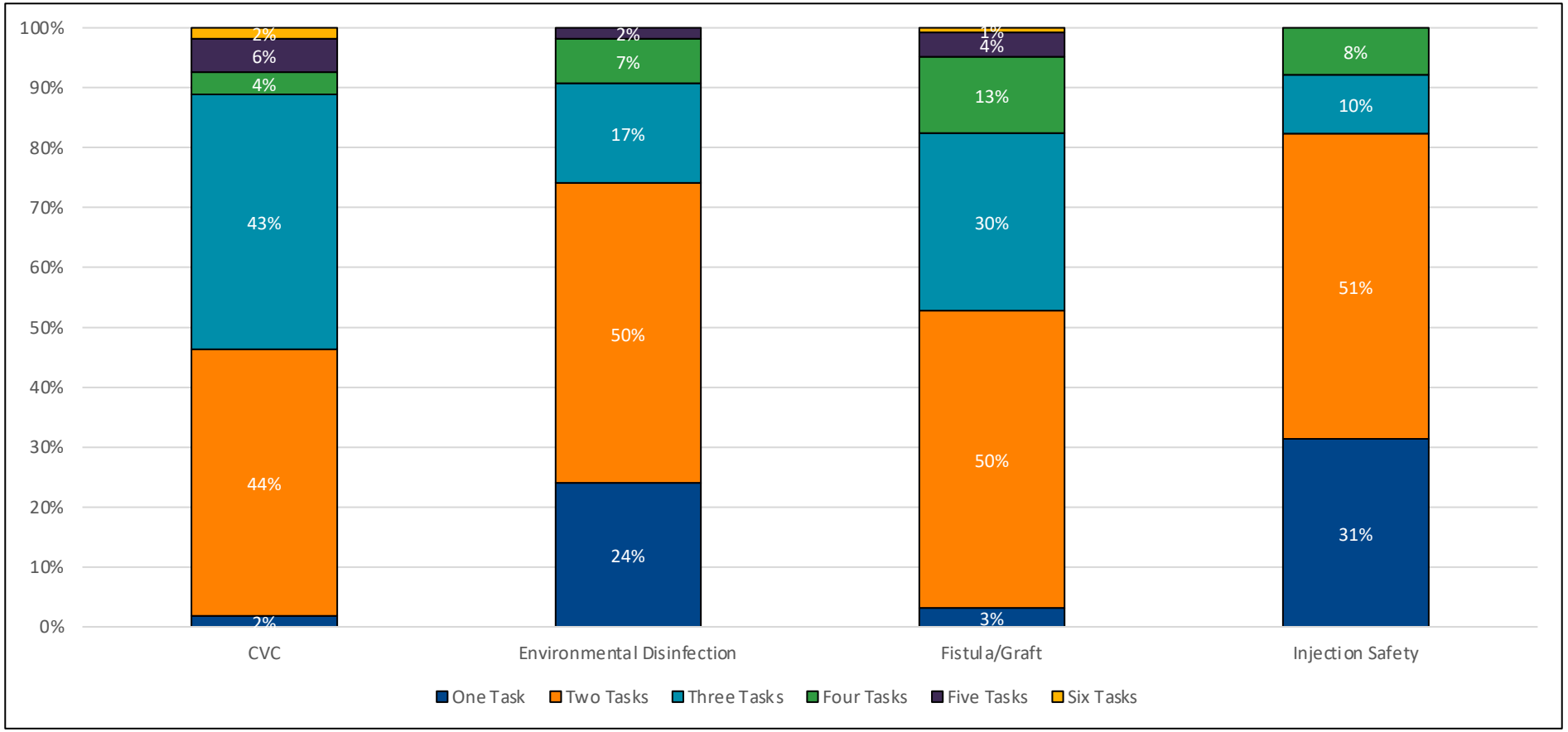
Alarms increase the need for hand hygiene and are often NOT matched to work-flow



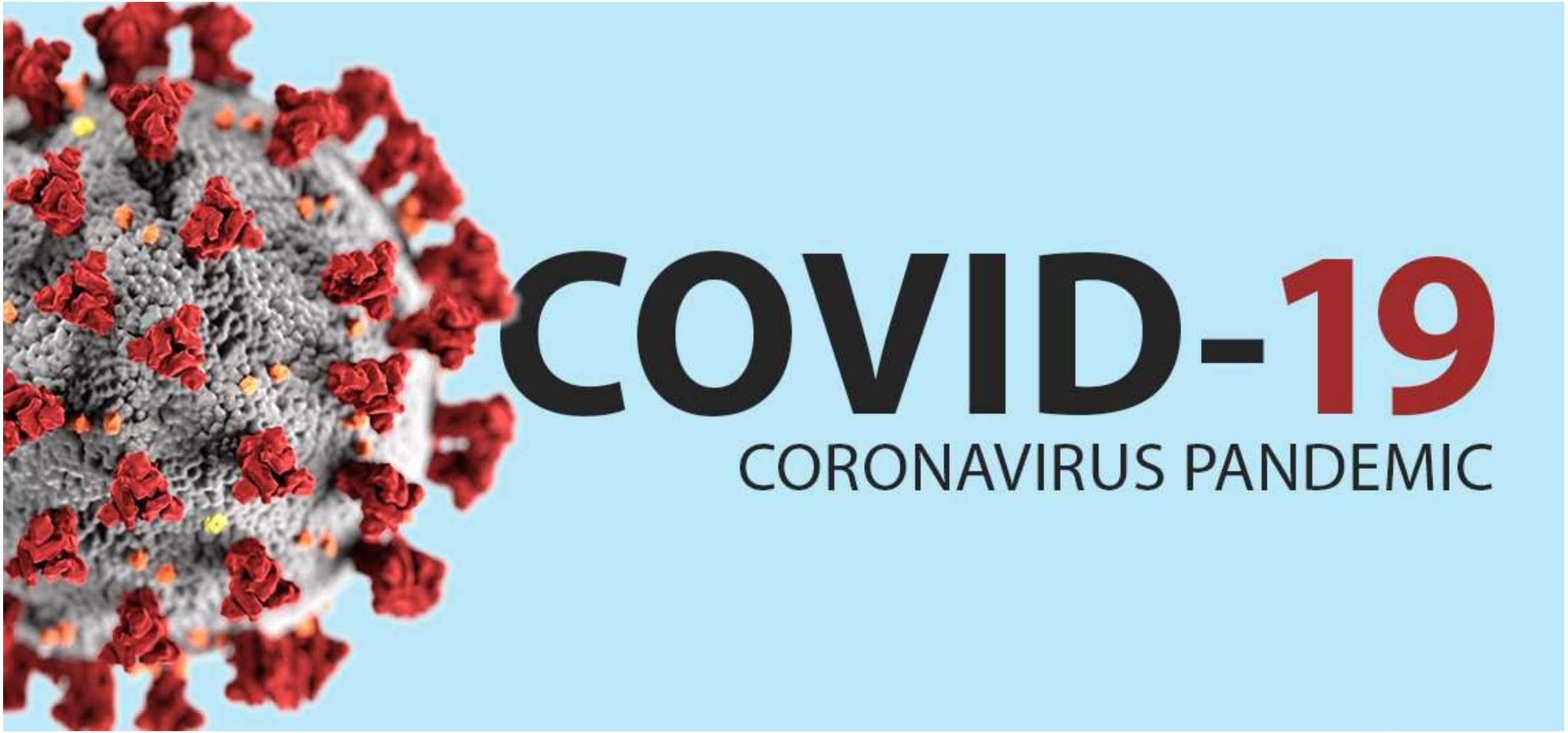
Machines are designed to be touched (touch screen). BUT every touch requires hand hygiene and increases the risk for skipped-steps

Task-Stacking and Task-Switching are Common



- *72.9% of the time 2 or more tasks are done simultaneously, and half the time 2 tasks are being completed at once.*

Infection Control in the Age of Coronovirus



Dialysis Patients are at Higher Risk of Acquiring COVID-19

- Co-Morbidities: Diabetes, Obesity, BP, CVD
- Frailty
- Age
- Immune Status
- In-Center
  - Cannot Social Distance: frequent exposure to staff and patients
  - Transportation

Hemodialysis Transportation

- 2013 USRDS

- Private cars (drove themselves) 25.3%


- Public transportation (bus/metro/taxi) – 7.9 %


- Help from others (van, ambulance etc) – 66.8%

West London Dialysis
Corbett et al, JASN 2020 August 31 (8):1815

- 1,530 dialysis patients
- 300 developed COVID-19 (19.6%)
- More likely among in-center than home dialysis patients
- Clustering in specific dialysis units and shifts
- High rates of nursing staff illness
- Modeling suggested that measures implemented reduced transmission

28-day case fatality rate
Dialysis patients

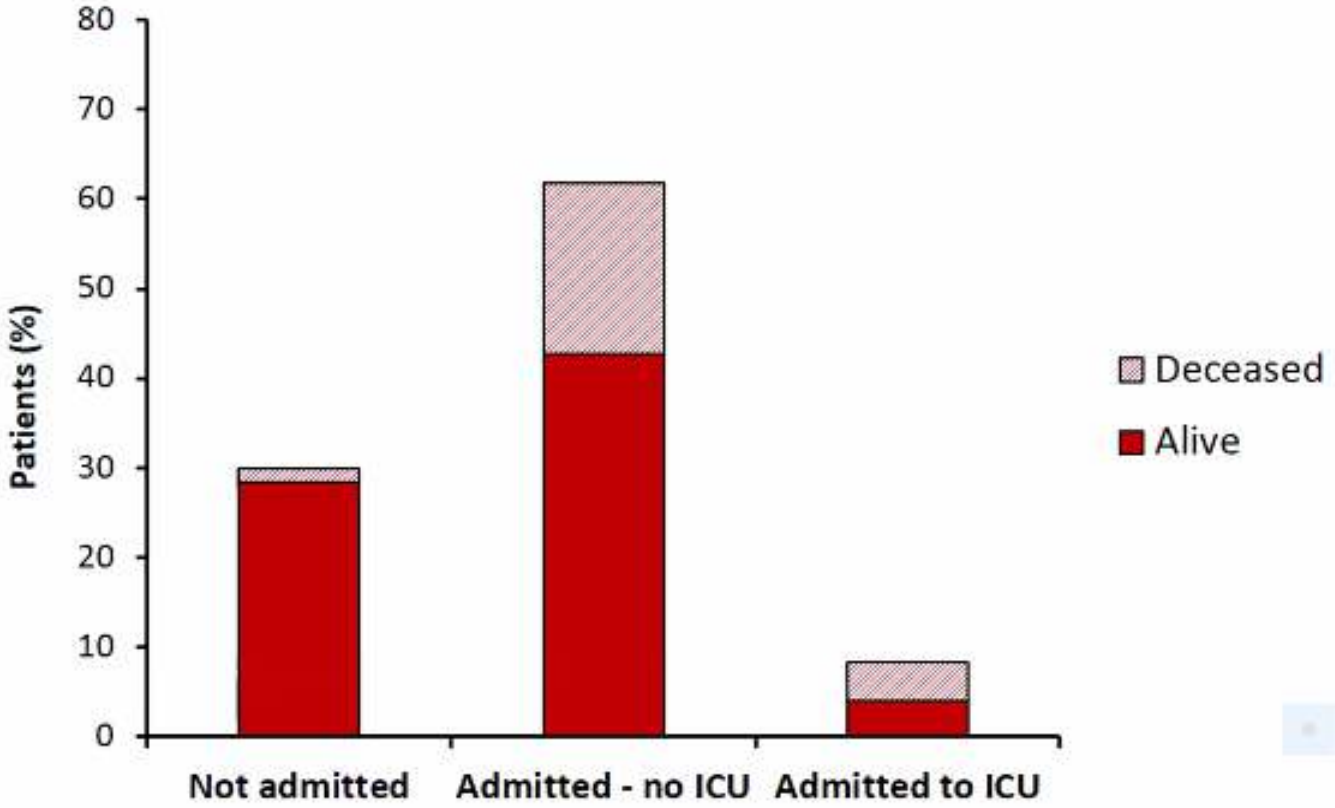
All patients: 25%

Not admitted patients: 5%

Hospitalized patients: 33%

Patients admitted to ICU: 53%

Survival according to admission status



Lessons Learned: Outpatient Dialysis

- Come to dialysis
- Call in ahead of your treatment if you are have fever, cough, etc.
- Protect yourself at home: face covering, social distancing, hand washing
- If you are sick: don't just tough it out at home: call your doctor. Come to hospital
- Hemodialysis facility lessons
  - Transportation: anticipate and educate
  - Segregate proven COVID-19 and PUI
  - Screen patients and staff every shift: questions, temp
  - No waiting rooms
  - Mental health resources
  - Prepare for the long haul (staff shortages, staff health, PPE)

Reporting PPE Shortages

- If your facility is concerned about a potential or imminent shortage of PPE, alert your state/local health department and local healthcare coalition, as they are best positioned to help facilities troubleshoot through temporary shortages.
- Link to identifying your state HAI coordinator: https://www.cdc.gov/hai/state-based/index.html
- Link to healthcare coalition/preparedness: https://www.phe.gov/Preparedness/planning/hpp/Pages/find-hc-coalition.aspx
-

Environmental Cleaning and Disinfection

- Routine cleaning and disinfection procedures are appropriate for COVID-19 in dialysis settings.
  - Ensure HCP have access to EPA-registered, hospital-grade disinfectants
    - Refer to the EPA-website for List N: Disinfectants for Use Against SARS-CoV-2: https://www.epa.gov/pesticide-registration/list-n-disinfectants-use-against-sars-cov-2
    - When using products from List N, facilities should ensure the products also have a bloodborne pathogen claim (e.g., hepatitis B, HIV).

- Any surface, supplies, or equipment located within 6 feet of symptomatic patients should be disinfected or discarded.

Patients Returning to Dialysis After Infection What Did We Find?

- Patients took a lot longer to feel better than we expected.
- Many patients had symptoms for up to 4 weeks and some up six weeks.
- Once the patient felt better, had improved symptoms and met the CDC criteria, they were moved back to to dialyze in their regular dialysis spots.

CDC: Return to Outpatient Dialysis (July 2020)

- **No Test-Based Strategy for Discontinuing Transmission-Based Precautions**
- **Symptom-Based Strategy for Discontinuing Transmission-Based Precautions.**
- *Patients with mild to moderate illness who are not severely immunocompromised:*
- At least 10 days have passed *since symptoms first appeared* **and**
- At least 24 hours have passed *since last* fever without the use of fever-reducing medications **and**
- Symptoms (e.g., cough, shortness of breath) have improved
- Note: For patients who are **not severely immunocompromised**[1] and who were **asymptomatic** throughout their infection, Transmission-Based Precautions may be discontinued when at least 10 days have passed since the date of their first positive viral diagnostic test.
- *Patients with severe to critical illness or who are severely immunocompromised*[1]*:*
- At least 20 days have passed *since symptoms first appeared* **and**
- At least 24 hours have passed *since last* fever without the use of fever-reducing medications **and**
- Symptoms (e.g., cough, shortness of breath) have improved
-

SARS CoV-2 Vaccine

1. Is it safe for dialysis patients to receive this vaccine (and how do we know)?

2. Will dialysis patients mount a vigorous antibody response?

3. Will the vaccine protect dialysis patients with possibly suppressed immune systems as well as it protects others?

4. What should we be telling our patients about the facts we know and don’t know?

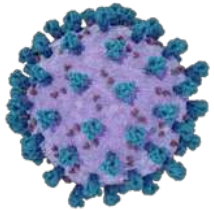
5. What can we do to help both patients and staff feel comfortable with this vaccine?

Long Haulers

- Patients have had systemic symptoms months after infection
- Neurologic
  - Fatigue, fuzzy head, short-term memory loss
  - Myalgia
  - Tremors
- Fevers; night sweats
- GI symptoms: nausea
- Bruising
- Arrhythmia
- Pain with deep breath

Summary

- Dialysis patients are at particular risk for COVID-19
- Home dialysis appears advantageous
- Dialysis patients may suffer neurologic, cardiac, GI, liver, clotting sequellae
- Long-haulers: How long? What can be done?
- Need clarity: What is the meaning of persistent + PCR in dialysis?
- Need data: Safety and Efficacy of SARS CoV-2 vaccines



ROLE OF NOVEL EXTRACORPOREAL THERAPIES

Saturday, March 6

16:25 – 16:50

Thiago Reis, MD

-Research Affiliate at the International Renal Research Institute Vicenza - IRRIV - Vicenza, Italy.

-Head of Nephrology and Kidney Transplantation at Clínica de Doenças Renais de Brasília, Brazil.

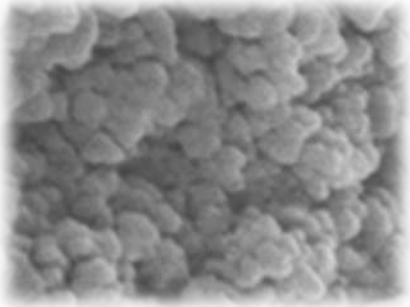
-Department of AKI – Brazilian Society of Nephrology.

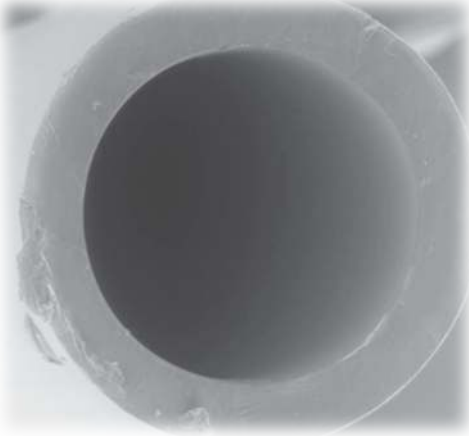
-PhD Candidate, Molecular Pharmacology Laboratory, University of Brasília – UnB.

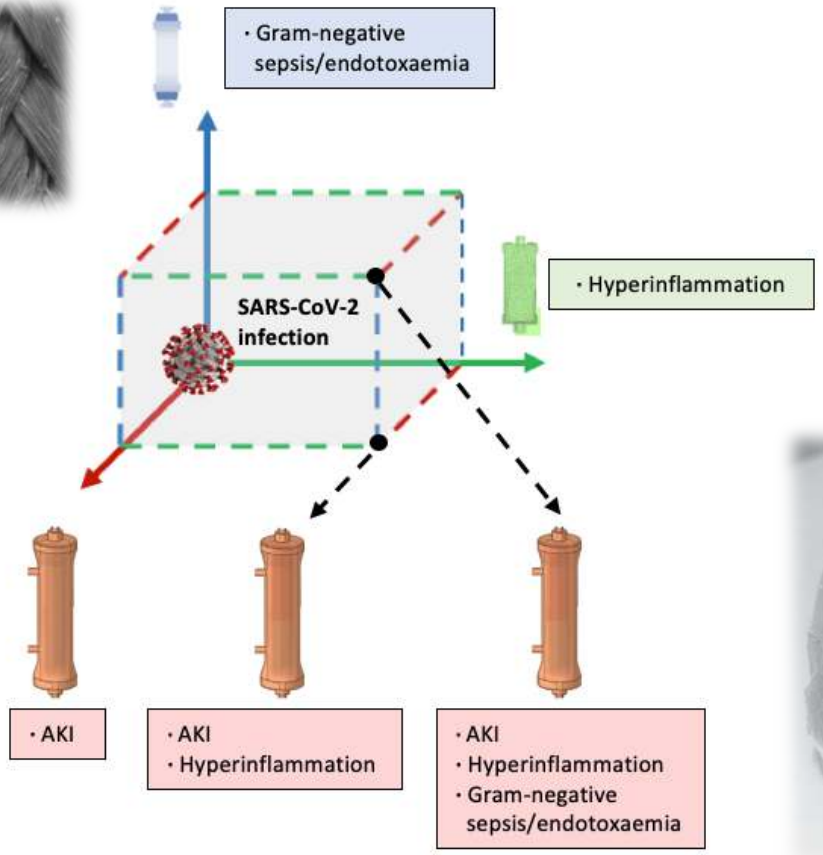
CONFLICT OF INTERESTS DISCLOSURE

In the last 3 years, TR has received funding for lectures, been consultant or part of advisory boards for Baxter, B.Braun, Contatti Medical (CytoSorb), Eurofarma and Jafron.

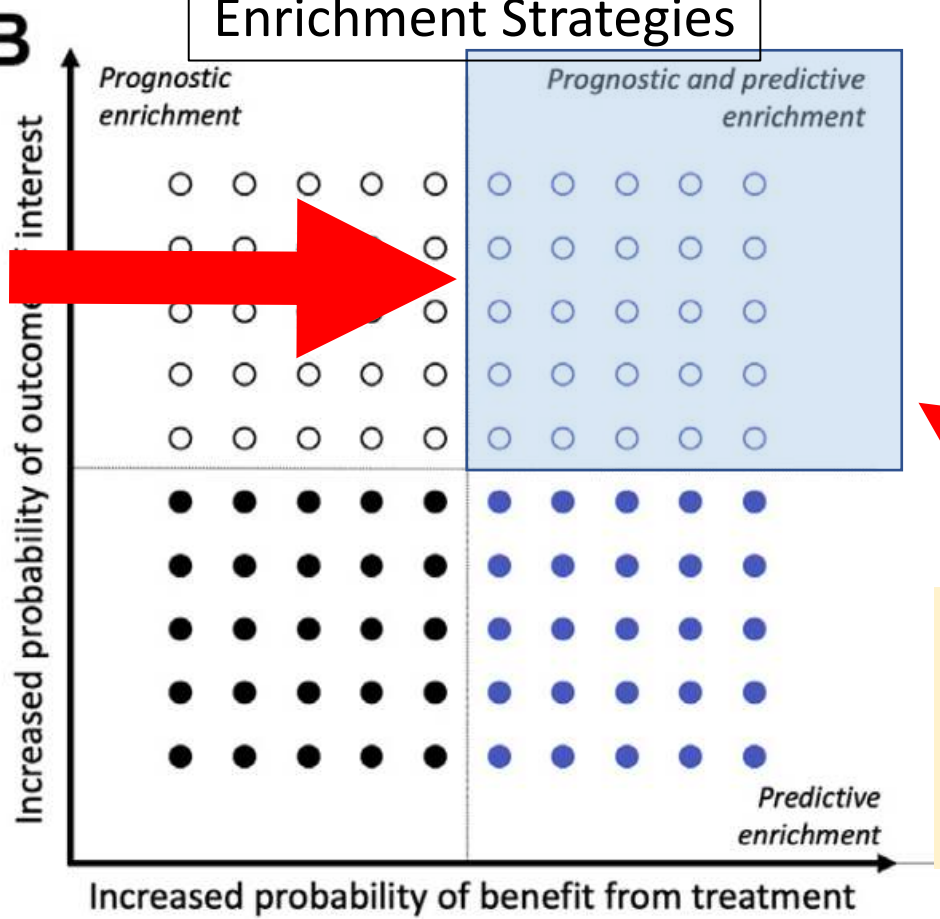
TRIDIMENSIONAL BLOOD PURIFICATION







Enrichment Strategies



Outcomes

NOT MORTALITY!!!

- PaO_2/FiO_2 increment
- Ventilator-free days
- Weaning of Noradrenaline

Patient Selection

BIOMARKERS

- [TIMP-2]•[IGFBP7]
- NGAL
- IL-6
- Endotoxin Activity

Sarma A, Calfee CS, Ware LB. Biomarkers and Precision Medicine: State of the Art. Crit Care Clin. 2020 Jan;36(1):155-165. doi: 10.1016/j.ccc.2019.08.012. Epub 2019 Oct 22.

Severely ill COVID-19 patient with hyperinflammation

EBP INITIATION

Clinical Criteria
- Respiratory Index < 300
- New onset of LV dysfunction
- Acute kidney injury
- Fever
- Shock

Laboratory Criteria
- [TIMP-2]•[IGFBP7]
- NGAL
- Lymphocyte count
- Ferritin
- Lactate dehydrogenase
- D-dimer
- C-reactive protein
- Myoglobin
- Troponin
- IL6
- Procalcitonin
- Endotoxin activity*
- Endotoxin concentration*
- Culture-proven Gram-negative sepsis*

EBP MONITORING

Clinical Criteria
- Respiratory Index
- LV ejection fraction
- Kidney function
- Fever
- Shock

Laboratory Criteria
- [TIMP-2]•[IGFBP7]
- NGAL
- Lymphocyte count
- Ferritin
- Lactate dehydrogenase
- D-dimer
- C-reactive protein
- Myoglobin
- Troponin
- IL6
- Procalcitonin
- Endotoxin activity*
- Endotoxin concentration*
- Culture-proven Gram-negative sepsis*

EBP DISCONTINUATION

Consider following manufacture's instructions.

Usually for cytokine removal:

3 consecutive days
2 to 12 hours

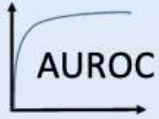
Usually for endotoxin removal:

2 consecutive days
2 to 4 hours

Evaluate re-prescription accordingly to patient's evolution

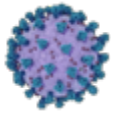
Research agenda

-Validate clinical and laboratory plausible criteria for EBP initiation, monitoring and discontinuation.
-Apply in the context of RCT



Retrospective

Single-center



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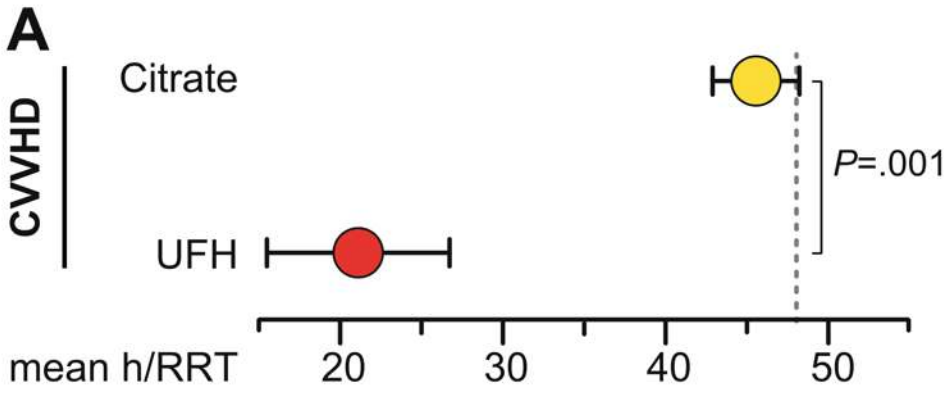
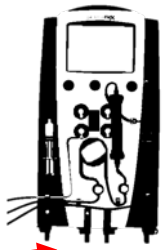
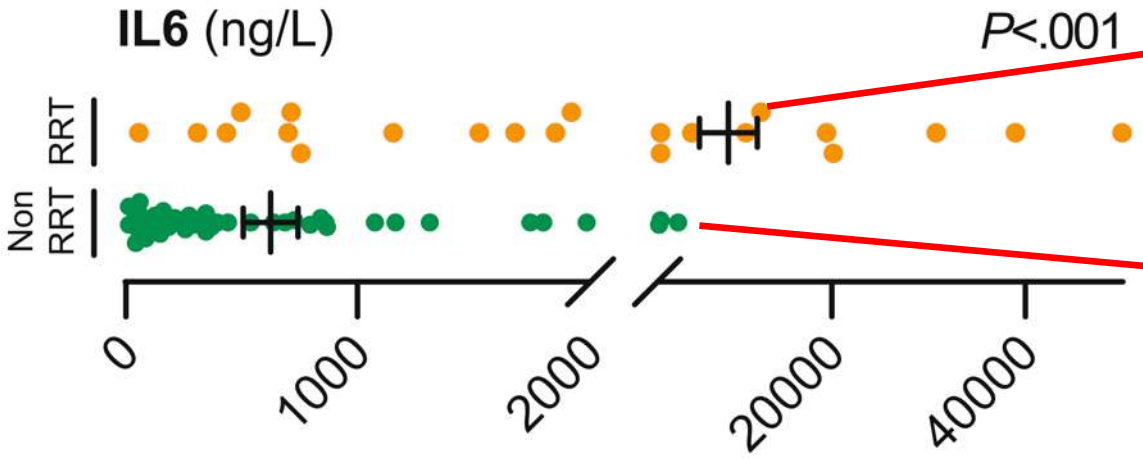
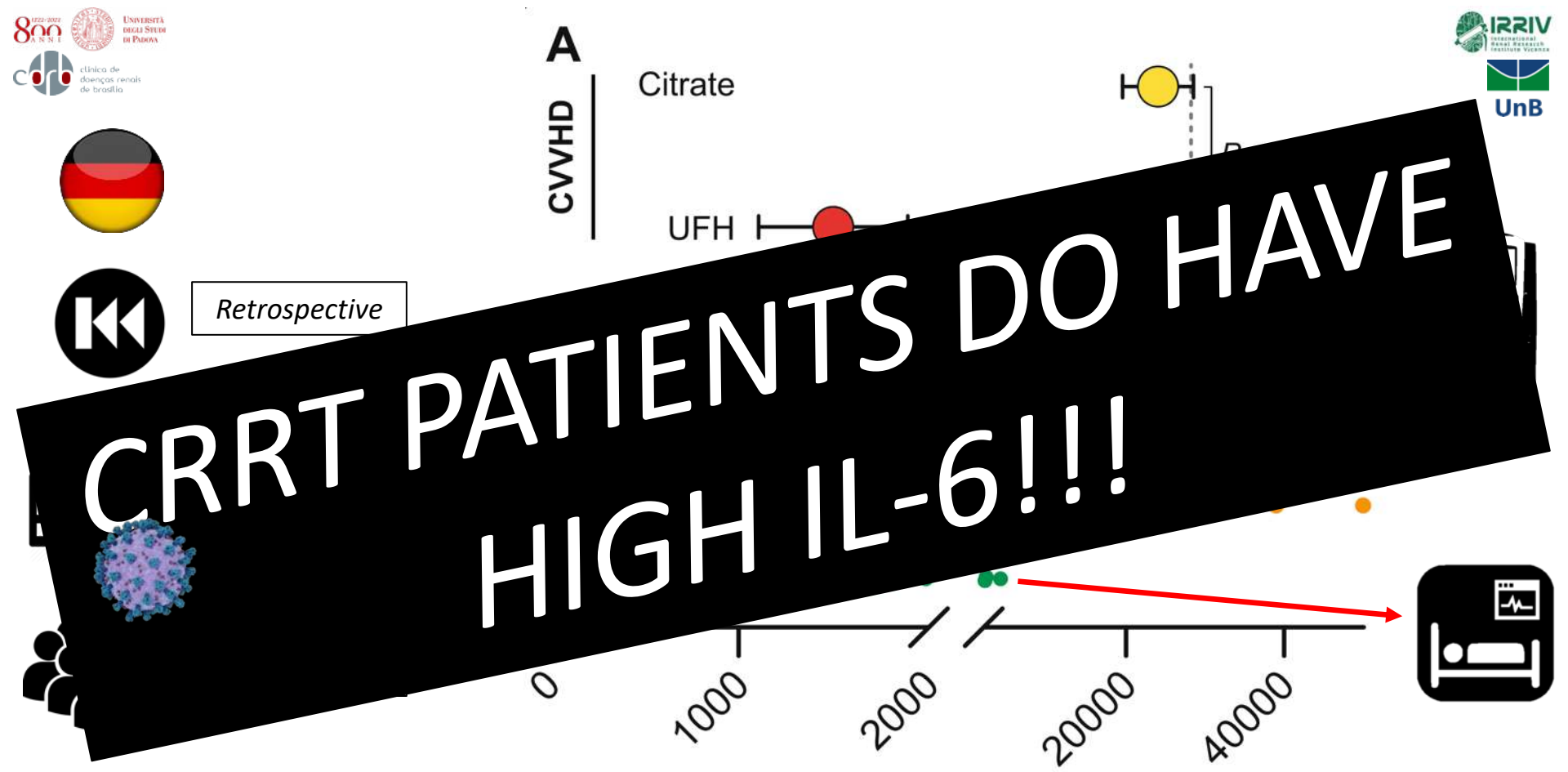




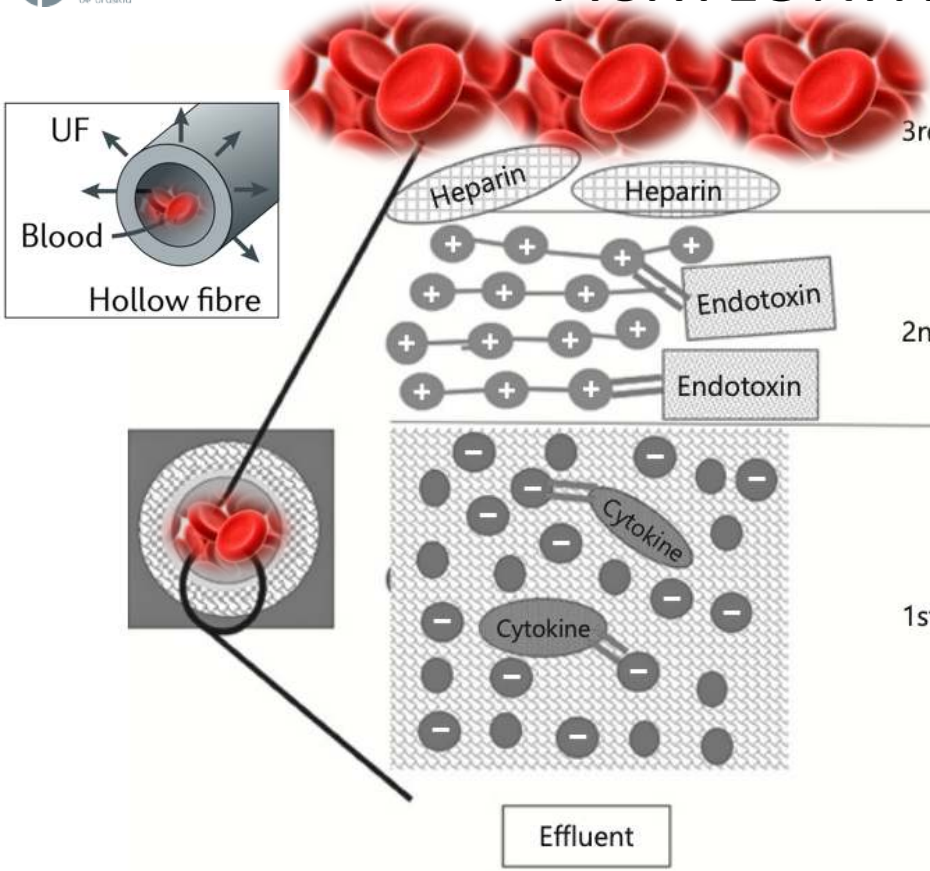


Arnold F, Westermann L, Rieg S, et al. Superior anticoagulation strategies for renal replacement therapy in critically ill patients with COVID-19: a cohort study. BMC Nephrol. 2020; 21: 486. Published online 2020 Nov 16



Arnold F, Westermann L, Rieg S, et al. Superior anticoagulation strategies for renal replacement therapy in critically ill patients with COVID-19: a cohort study. BMC Nephrol. 2020; 21: 486. Published online 2020 Nov 16

ACRYLONITRILE – AN69

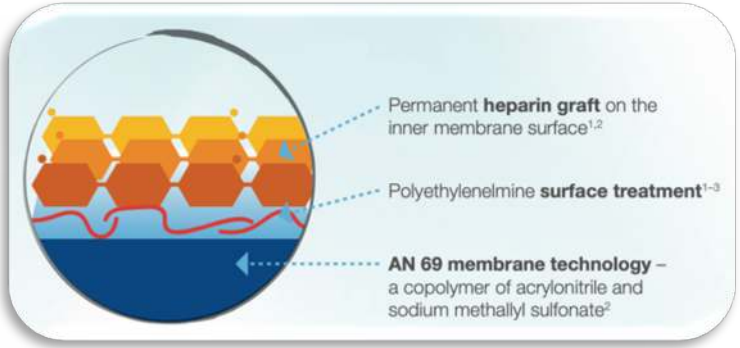


3rd layer	Heparin grafting	Reduce local thrombogenicity
2nd layer	Multiple layers of PEI	Improve biocompatibility Adsorb endotoxins
1st layer	AN69 copolymere hydrogel structure	Adsorb cytokines Remove solutes via convection through membrane pores (cut-off 40 kDa)

1.Saito A, Kawanishi H, Yamashita AC, Mineshima M (eds): High-Performance Membrane Dialyzers. Contrib Nephrol. Basel, Karger, 2011, vol 173, pp 119–129
2.Monard C, Rimmelé T, Ronco C. Extracorporeal Blood Purification Therapies for Sepsis. Blood Purif. 2019;47 Suppl 3:1-14. doi: 10.1159/000499520. Epub 2019 Apr 11.

ACRYLONITRILE – AN69

Heparin



High density polyethylenimine (30 mg/m²) → *Endotoxins*

Polyacrylonitrile → Cytokines

1.Saito A, Kawanishi H, Yamashita AC, Mineshima M (eds): High-Performance Membrane Dialyzers. Contrib Nephrol. Basel, Karger, 2011, vol 173, pp 119–129
2.Monard C, Rimmelé T, Ronco C. Extracorporeal Blood Purification Therapies for Sepsis. Blood Purif. 2019;47 Suppl 3:1-14. doi: 10.1159/000499520. Epub 2019 Apr 11.

HYDROGEL - 17,000 m²

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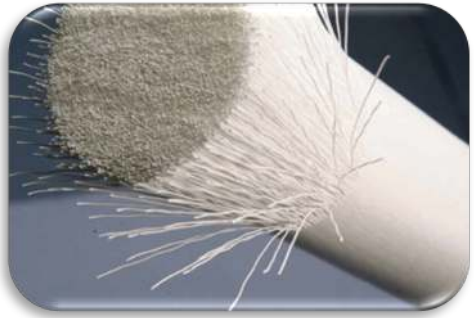

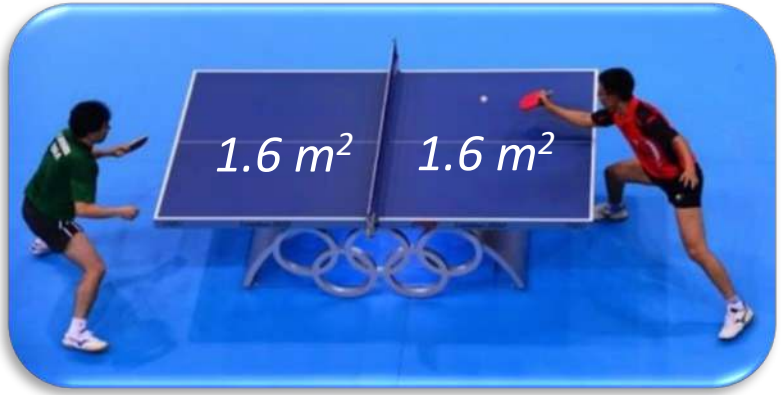

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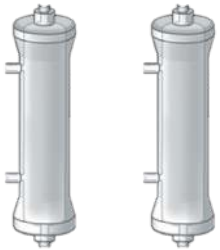
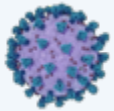


Feri M. "In vitro comparison of the adsorption of inflammatory mediators by blood purification devices": a misleading article for clinical practice?. Intensive Care Med Exp. 2019;7(1):5. Published 2019 Jan 9.

BLOOD PURIFICATION COVID-19

Prospective

Observational



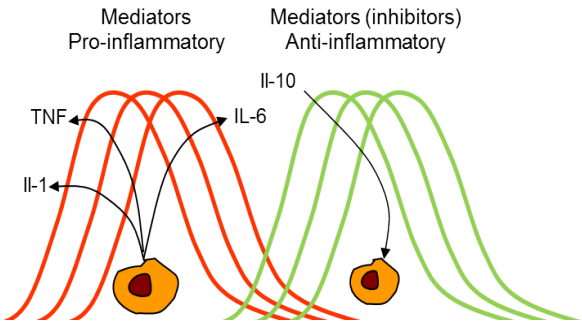
n=37

INDICATION TO START

AKI → 70%
-AKI Stage 2 → 23%
-AKI Stage 3 → 77%

Immunomodulation → 30%
AKI Stage 1

-Fluid overload → 40%
-Uremic control → 49%
-Electrolytes → 24%



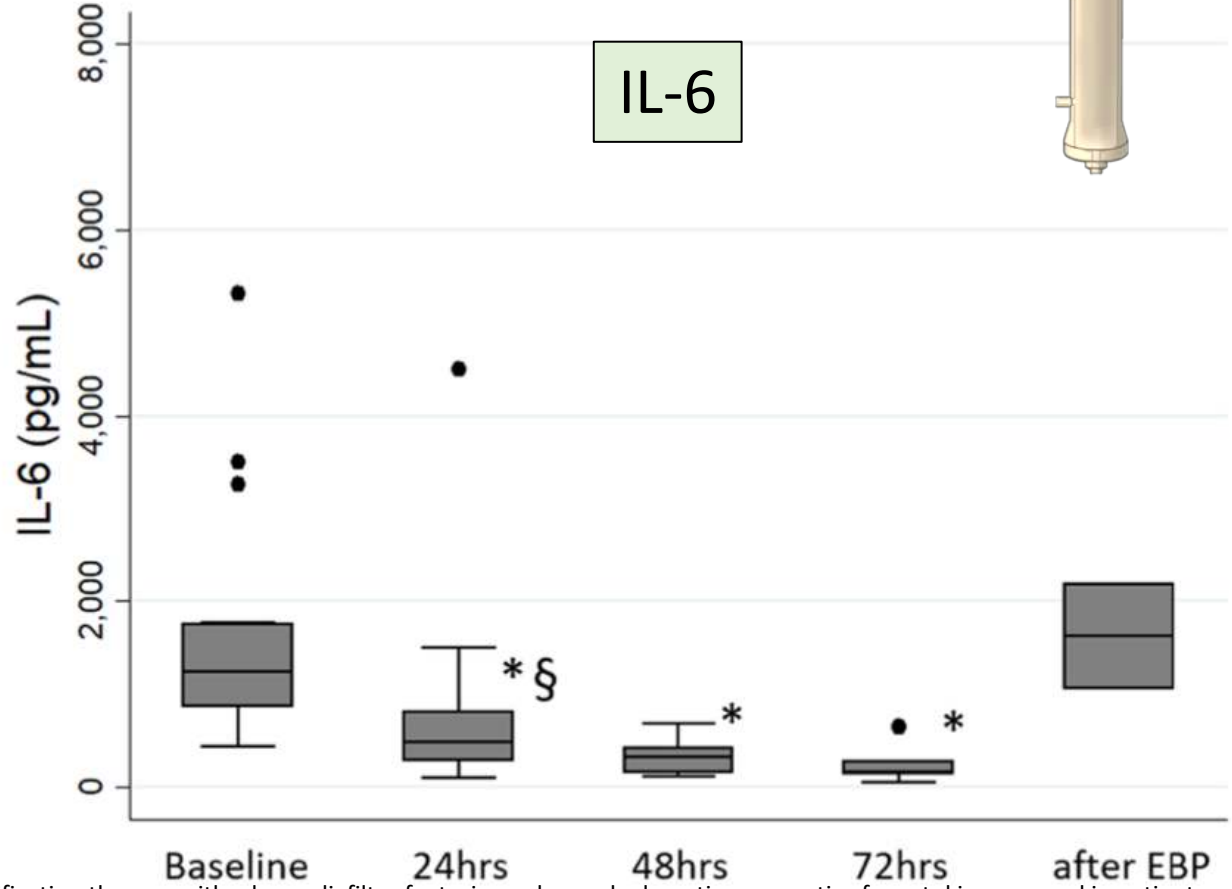
Villa G, Romagnoli S, De Rosa S, et al. Blood purification therapy with a hemodiafilter featuring enhanced adsorptive properties for cytokine removal in patients presenting COVID-19: a pilot study. Crit Care. 2020;24:605. Published 2020 Oct 12.

BLOOD PURIFICATION COVID-19

Prospective

Observational

n=37



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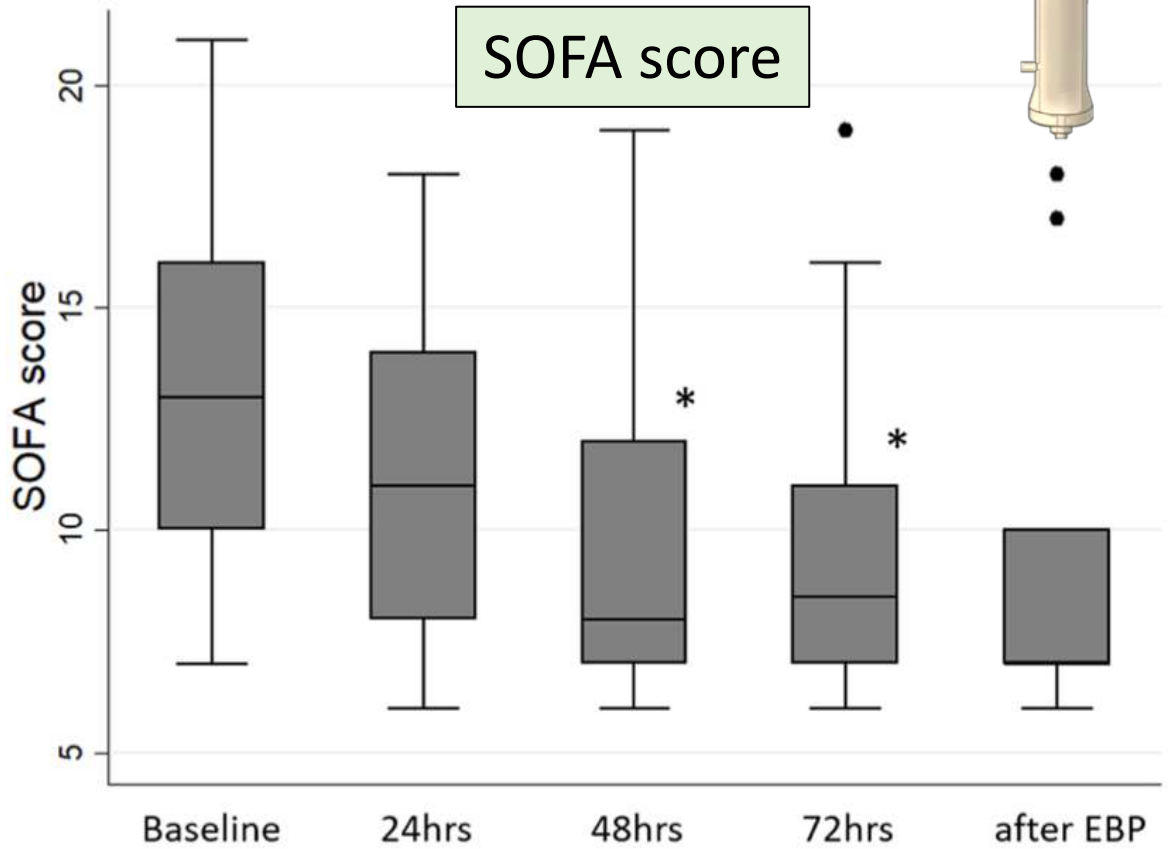
BLOOD PURIFICATION COVID-19

Prospective

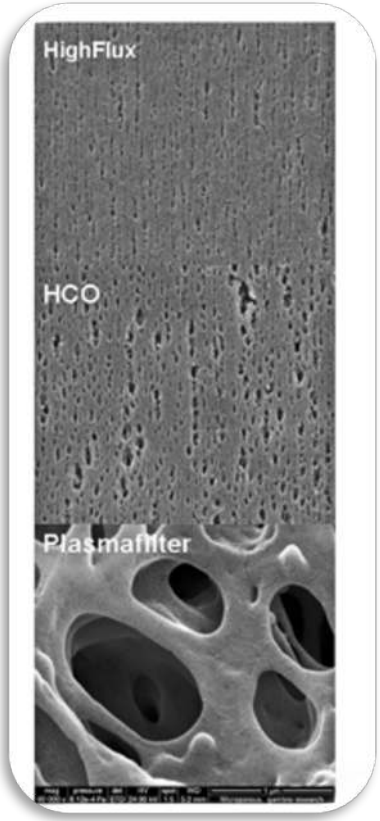
Observational

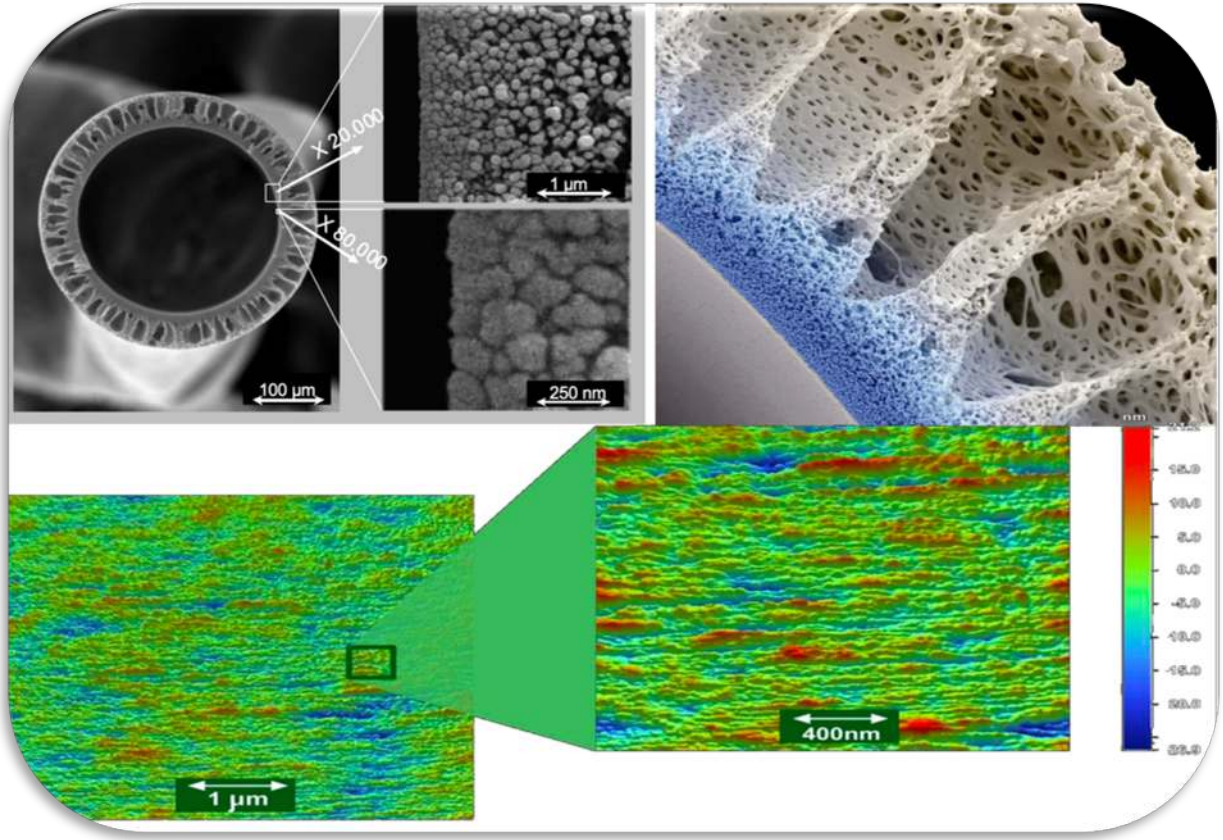
n=37



Villa G, Romagnoli S, De Rosa S, et al. Blood purification therapy with a hemodiafilter featuring enhanced adsorptive properties for cytokine removal in patients presenting COVID-19: a pilot study. Crit Care. 2020;24:605. Published 2020 Oct 12.

POLYETHERSULFONE





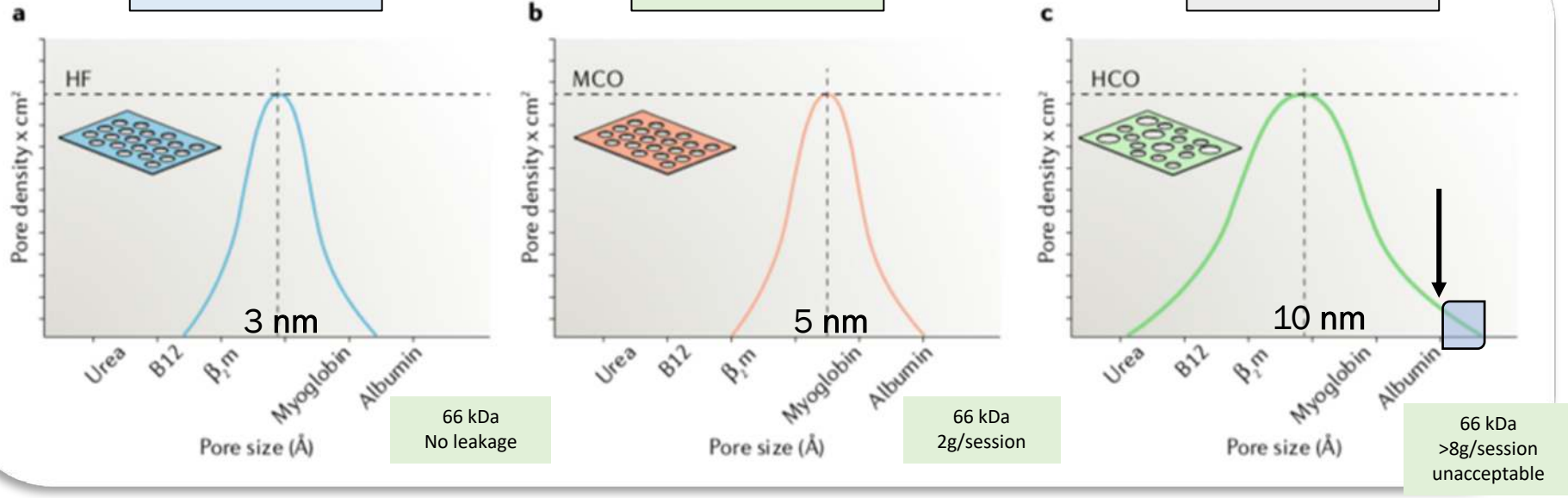
-Ronco C, Clark WR. Haemodialysis membranes. Nat Rev Nephrol. 2018;14(6):394-410.
Boschetti-de-Fierro et al. Extended characterization of a new class of membranes for blood purification: the high cut-off membranes. Int J Artif Organs. 2013 Jul;36(7):455-63.

ALBUMIN LEAKAGE

High-flux
MWRO → 2,000 Da
MWCO → 15,000 Da

Medium cutoff
MWRO → 20,000 Da
MWCO → 60,000 Da

High cutoff
MWRO → 15,000 Da
MWCO → 170,000 Da



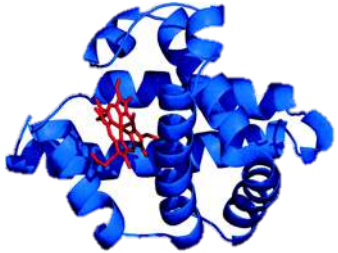
66 kDa
No leakage

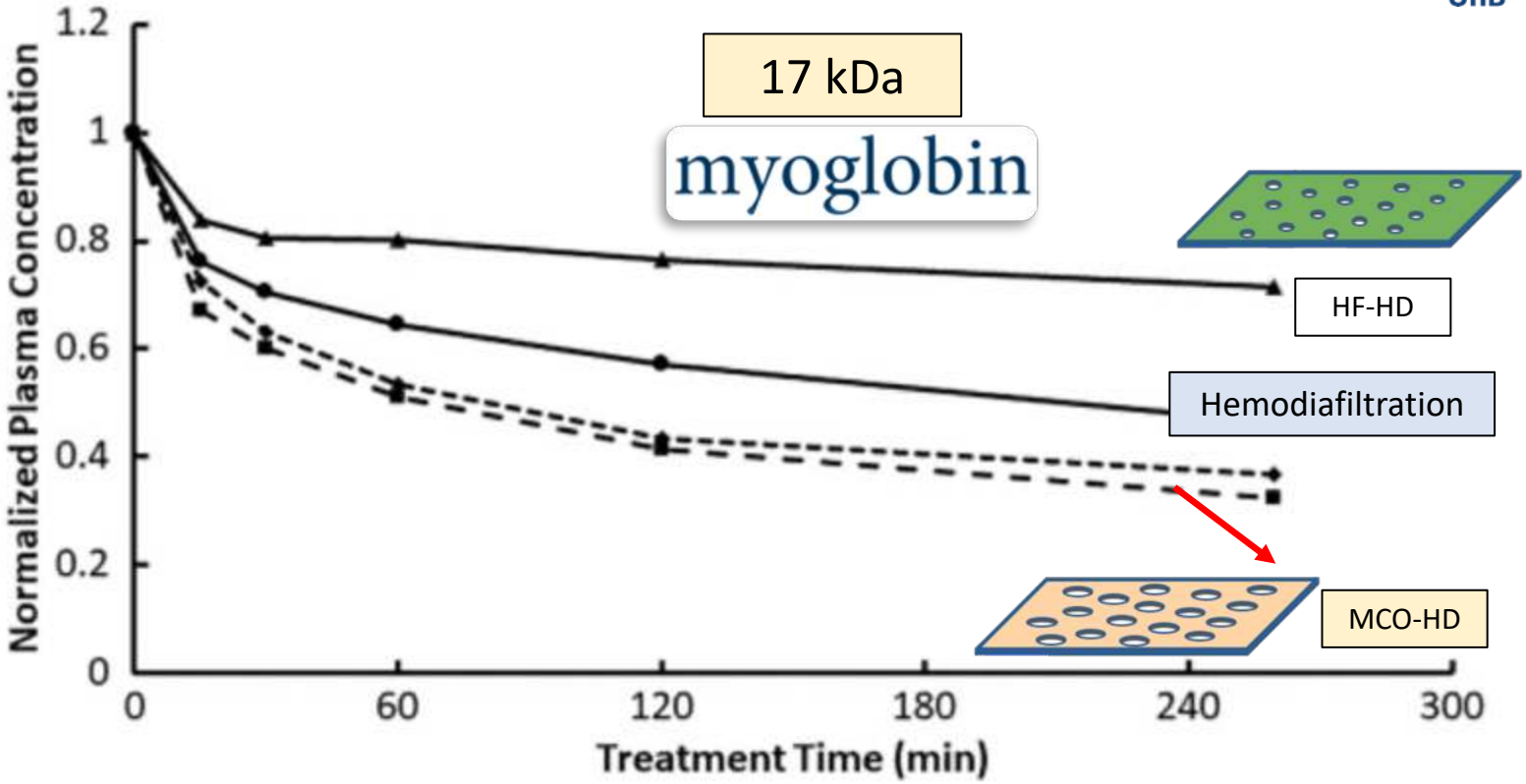
66 kDa
2g/session

66 kDa
>8g/session
unacceptable

-Ronco C, Clark WR. Haemodialysis membranes. Nat Rev Nephrol. 2018;14(6):394-410.
Boschetti-de-Fierro et al. Extended characterization of a new class of membranes for blood purification: the high cut-off membranes. Int J Artif Organs. 2013 Jul;36(7):455-63.

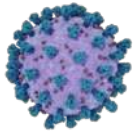
MEDIUM CUTOFF vs HIGH-FLUX





Leypoldt JK et al. Intradialytic kinetics of middle molecules during hemodialysis and hemodiafiltration. Nephrol Dial Transplant. 2019;34(5):870-877.

WORLD HEALTH ORGANIZATION DECLARES

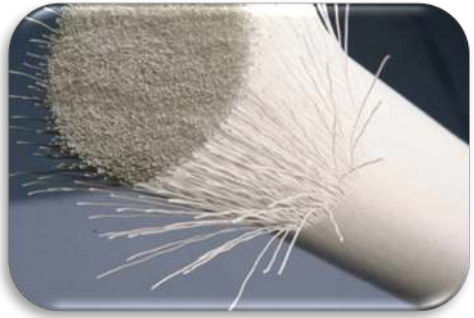


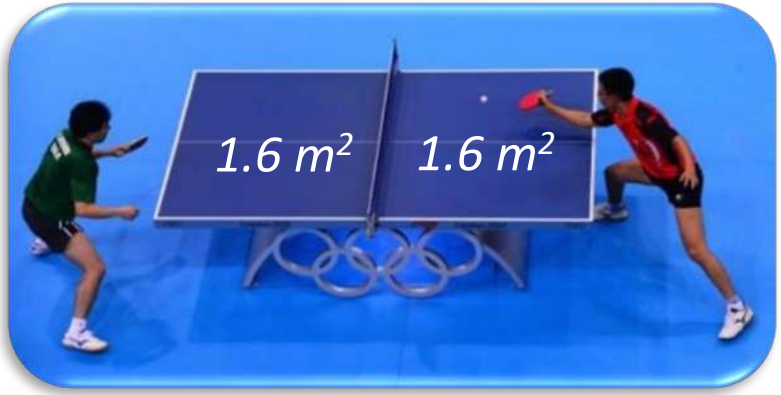
REMOVE CYTOKINES!!!

Reis T. This was intended to be a joke (haha). Please, don't get me wrong. 2021.

HEMOPERFUSION – 60,000 m²

=





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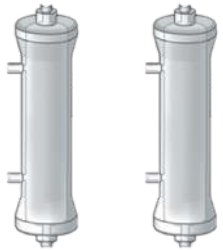


Feri M. "In vitro comparison of the adsorption of inflammatory mediators by blood purification devices": a misleading article for clinical practice?. Intensive Care Med Exp. 2019;7(1):5. Published 2019 Jan 9.

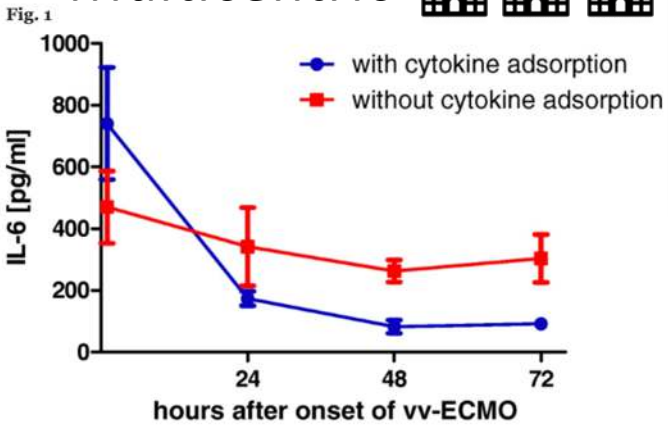
HEMOPERFUSION + ECMO

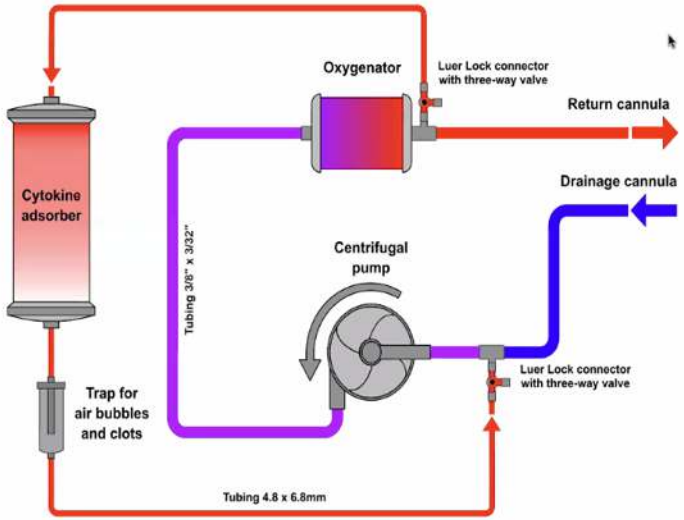
CYCOV-II

-Randomized

-Open-label

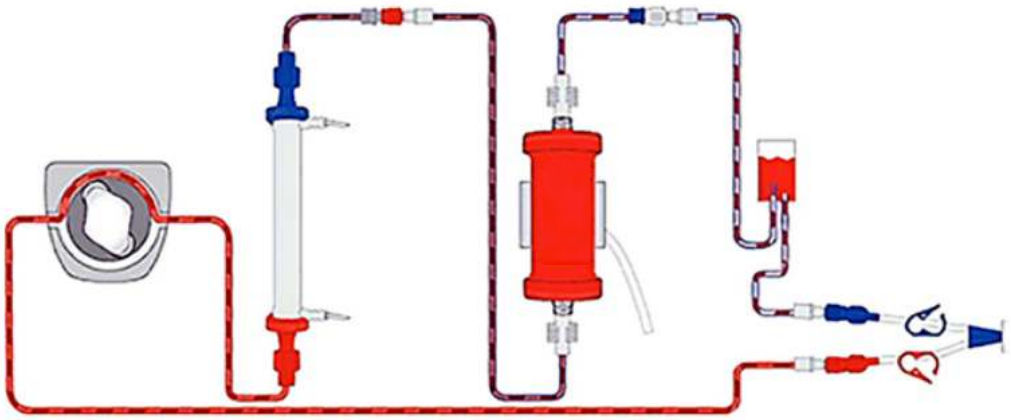
-Multicentric

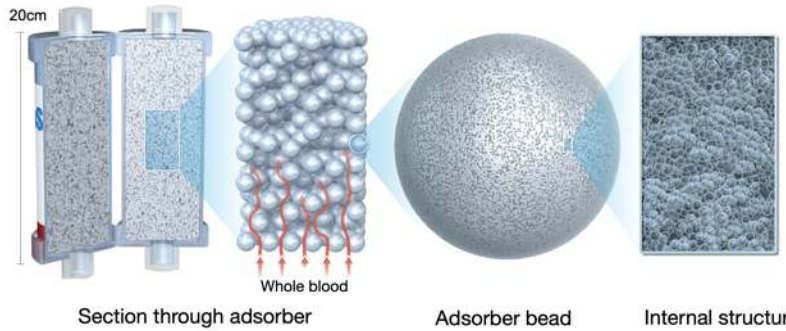




1.Rieder M et al. Cytokine Adsorption in Severe Acute Respiratory Failure Requiring Veno-Venous Extracorporeal Membrane Oxygenation. ASAIO J. 2020 Nov 9.
2.Rieder M et al. Cytokine adsorption in patients with severe COVID-19 pneumonia requiring extracorporeal membrane oxygenation. Crit Care. 2020;24(1):435. Published 2020 Jul 14.

HEMOPERFUSION + CRRT





1.Al Shareef K, Bakouri M. Cytokine Blood Filtration Responses in COVID-19 [published online ahead of print, 2020 May 28]. Blood Purif. 2020;1-9.
2.Reis T, unpublished data.

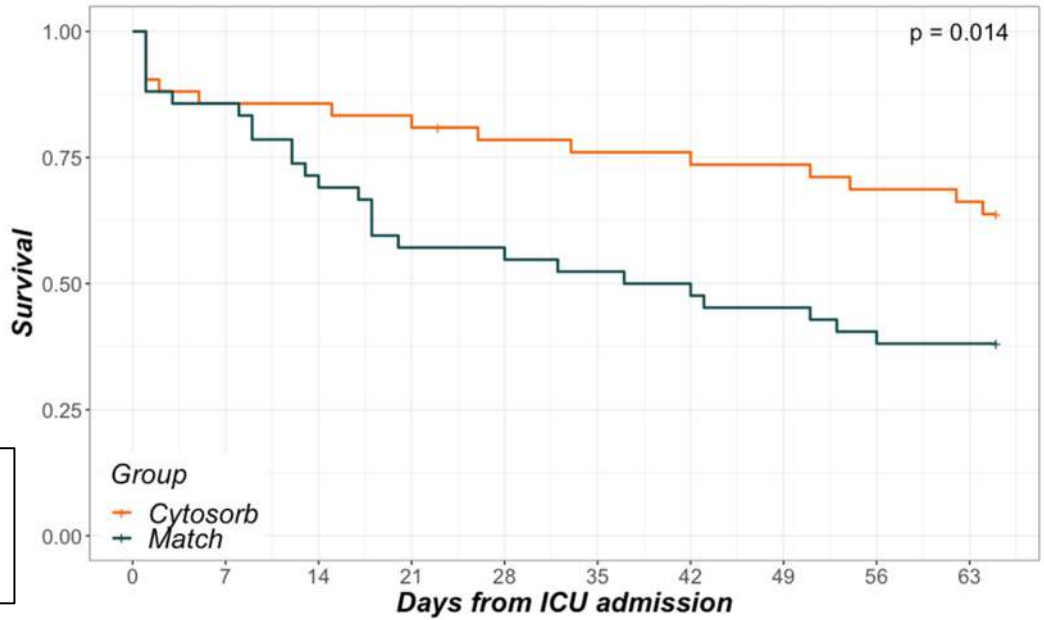
HEMOPERFUSION + CRRT

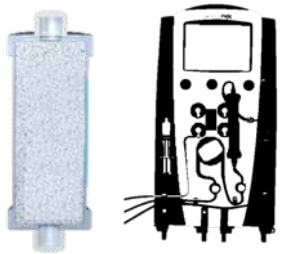
Not COVID-19

Retrospective

Single-center

CASE n=42
vs
CONTROL n=42





vs

Rugg C, Klose R, Hornung R, et al. Hemoadsorption with CytoSorb in **Septic Shock Reduces Catecholamine Requirements and In-Hospital Mortality**: A Single-Center Retrospective 'Genetic' Matched Analysis. Biomedicines. 2020;8(12):539. Published 2020 Nov 26.

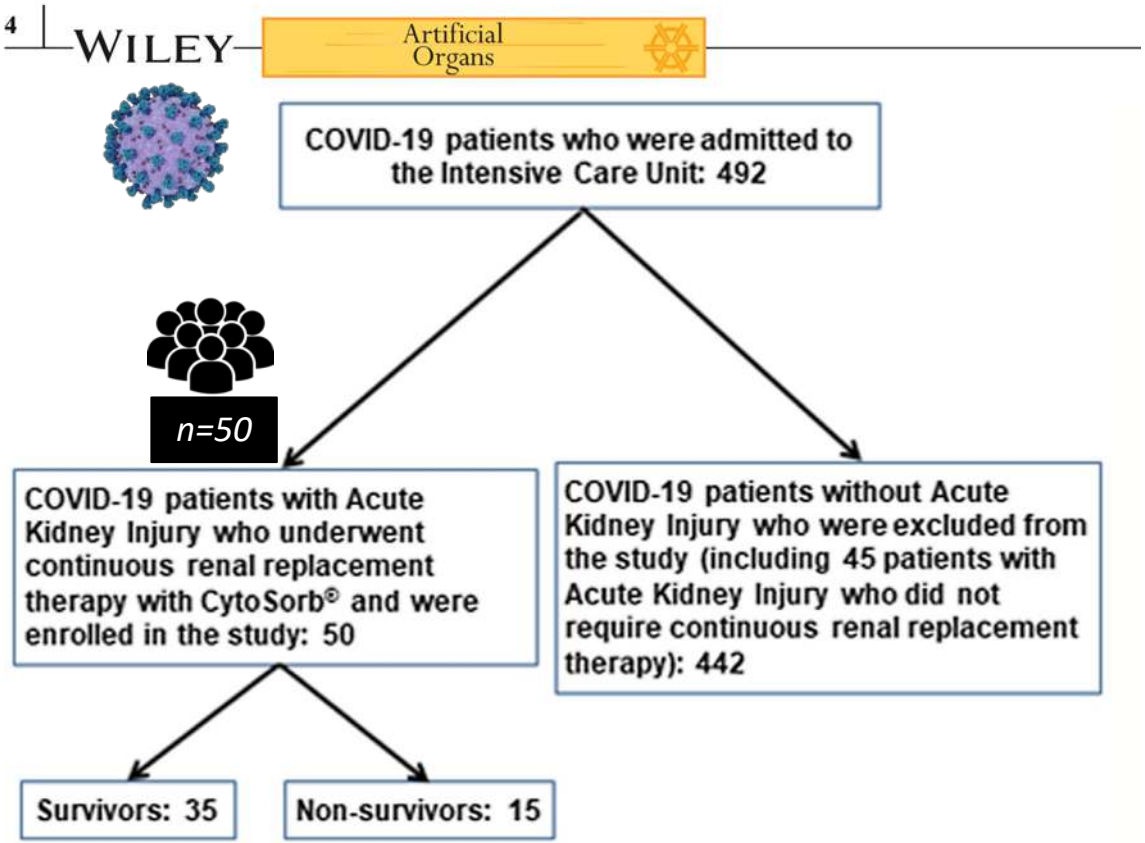
HEMOPERFUSION + CRRT

Case series

Retrospective

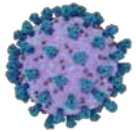
Single-center

CRRT
+
Hemoperfusion



Alharthy A, Faqihi F, Memish ZA, et al. Continuous renal replacement therapy with the addition of CytoSorb cartridge in critically ill patients with COVID-19 plus acute kidney injury: A case-series [published online ahead of print, 2020 Nov 15]. Artif Organs. 2020

GRETA ALSO DECLARED



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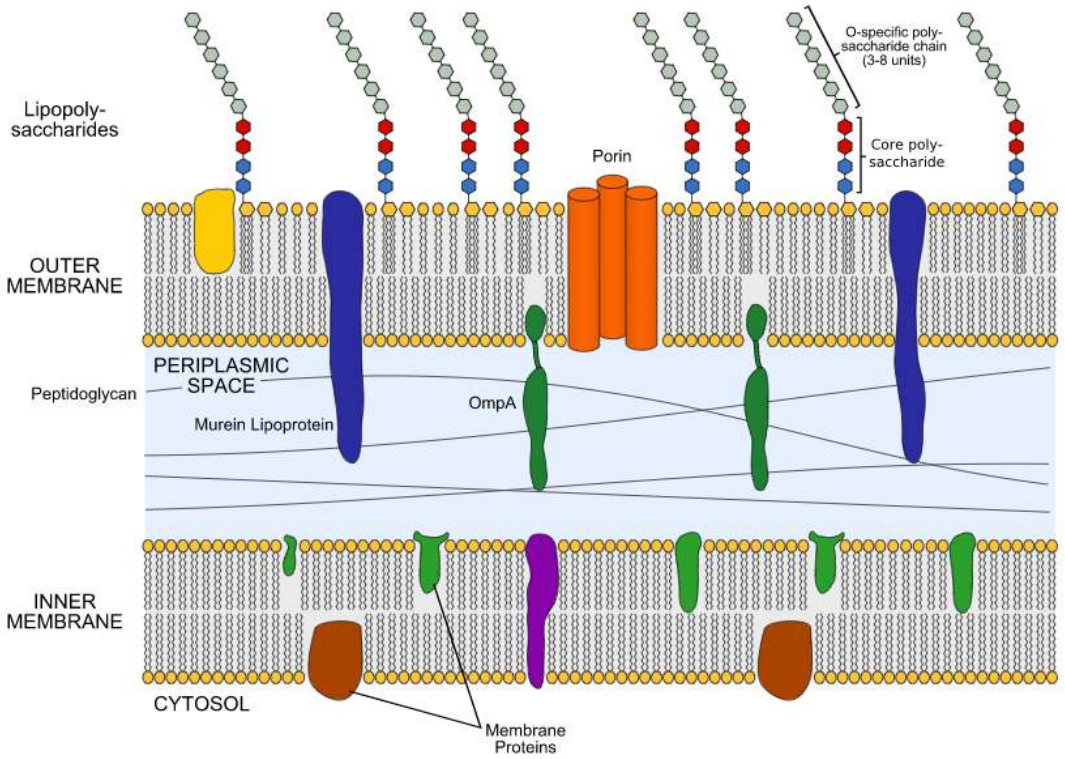
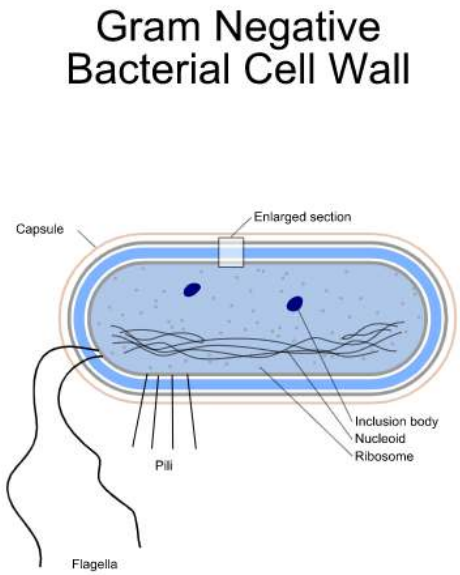
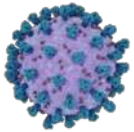
ENDOTOXINS
LIPOPOLYSACCHARIDES





Gorelik A, Illes K, Nagar B. Crystal structure of the mammalian lipopolysaccharide detoxifier. Proc Natl Acad Sci U S A. 2018;115(5):E896-E905.

ENDOTOXEMIA



Hospitalized with COVID-19
147

Source Population

→ No evidence of pneumonia

COVID-19 Pneumonia
53

→ No leftover samples

Fulfilled inclusion criteria
19

Final Cohort

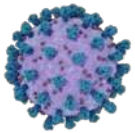
EAA >0.6

High EAA at day 1
8

Low EAA at day 1
11

1.Sirivongrangson et al. Endotoxemia and circulating bacteriome in severe COVID-19 patients. Intensive Care Med Exp. 2020 Dec; 8: 72. Published online 2020 Dec 7.
2.Katagiri D et al. Direct hemoperfusion using a polymyxin B-immobilized polystyrene column for COVID-19 [published ahead of print, 2020 Dec 15]. J Clin Apher. 2020

PMX-HEMOPERFUSION



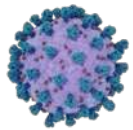
Case series

Retrospective

Multicenter

PMX Hemoperfusion

n=12



Case series

Retrospective

Single-center

PMX Hemoperfusion

n=12

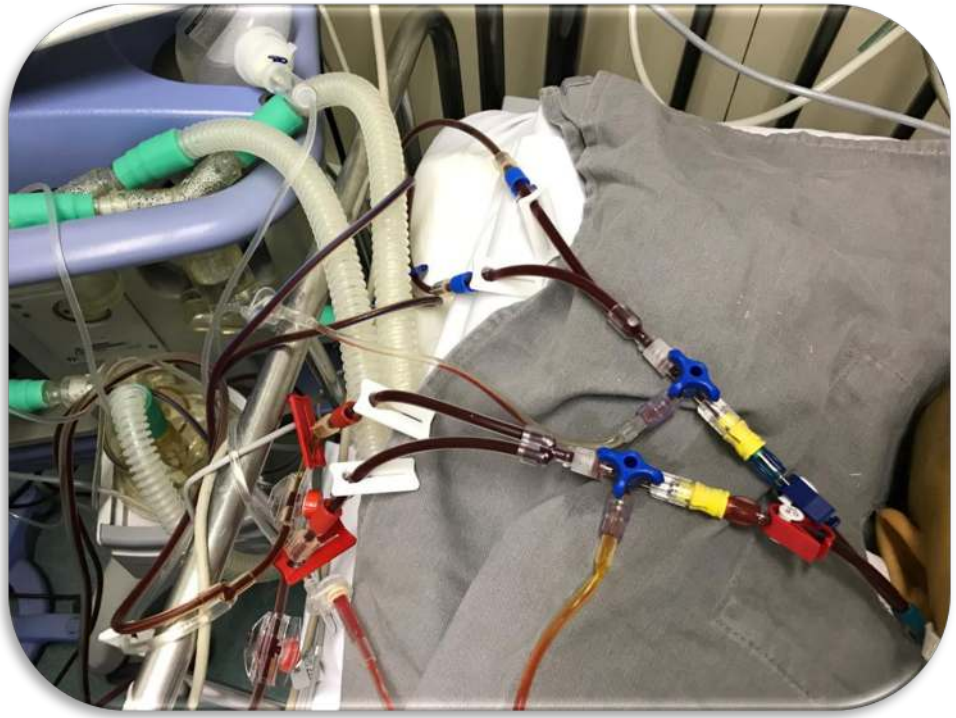
1. De Rosa S, Cutuli SL, Ferrer R, Antonelli M, Ronco C; COVID19 EUPHAS2 Collaborative Group. Polymyxin B hemoperfusion in COVID-19 Patients with endotoxic shock: Case Series from EUPHAS II registry [published online ahead of print, 2020 Dec 30]. Artif Organs. 2020
2.Katagiri D et al. Direct hemoperfusion using a polymyxin B-immobilized polystyrene column for COVID-19 [published ahead of print, 2020 Dec 15]. J Clin Apher. 2020

FAUCI DECLARED

GET RID OF ENDOTOXINS!!!

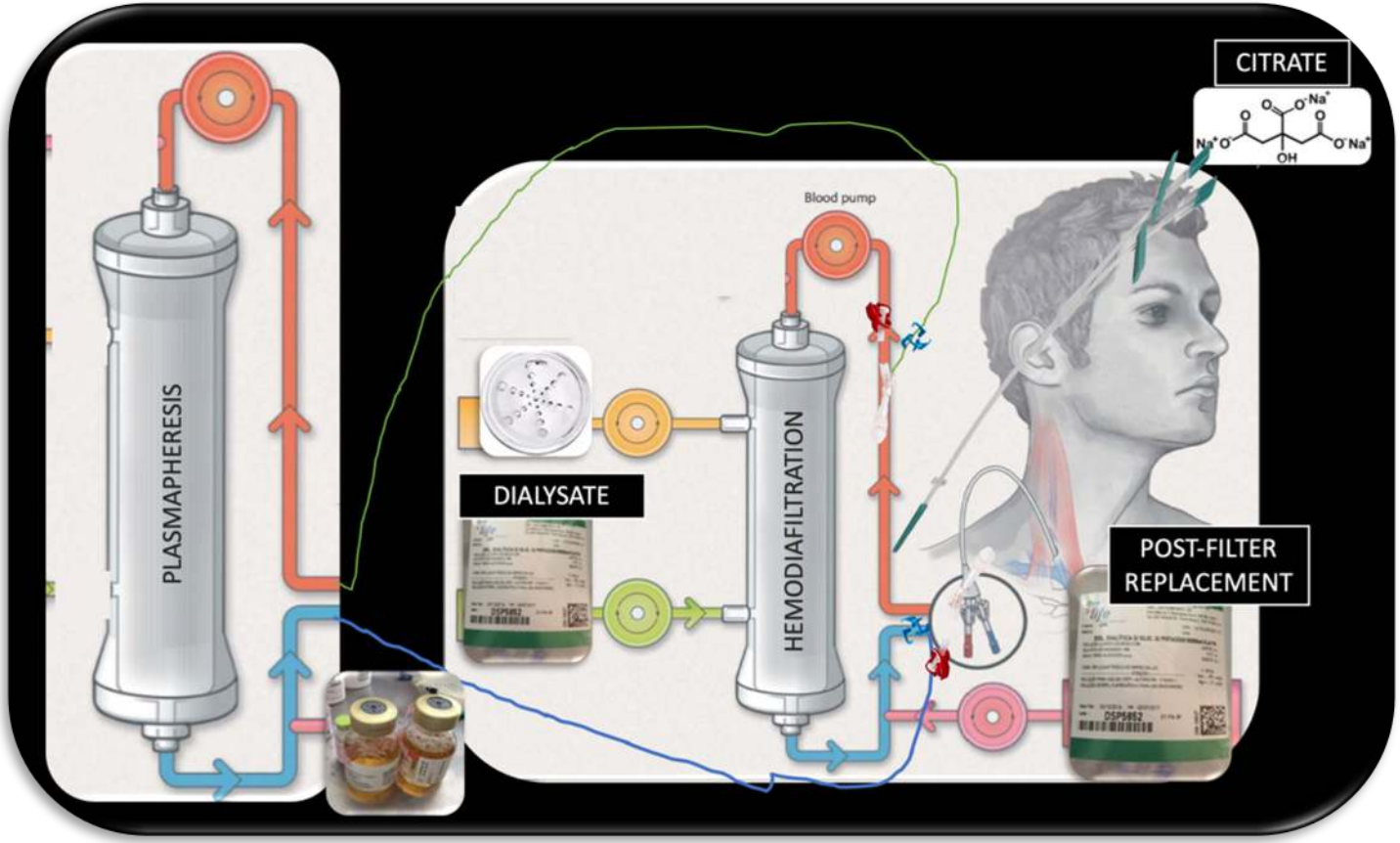
Reis T. This was intended to be a joke (haha). Please, don't get me wrong. 2021.

PLASMAPHERESIS + CRRT



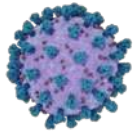
1.Gucyetmez B, Atalan HK, Sertdemir I, Cakir U, Telci L; COVID-19 Study Group. Therapeutic plasma exchange in patients with COVID-19 pneumonia in intensive care unit: a retrospective study. Crit Care. 2020;24(1):492. Published 2020 Aug 8.
2.Watanabe A, unpublished data.

PLASMAPHERESIS + CRRT



1.Gucyetmez B, Atalan HK, Sertdemir I, Cakir U, Telci L; COVID-19 Study Group. Therapeutic plasma exchange in patients with COVID-19 pneumonia in intensive care unit: a retrospective study. Crit Care. 2020;24(1):492. Published 2020 Aug 8.
2.Reis T, unpublished data.

PLASMAPHERESIS



Retrospective

D-dimer
Cutoff 2 mg/L

n = 73

Higher mortality in
TPE negative group

Table 2 Comparisons of laboratory parameters in pre and post-TPE procedure

	Pre-TPE	Post-TPE	*p*
WBC ($\times 10^3/\mu L$)	9.08 ± 4.1	9.14 ± 3.5	0.951
Neuc ($\times 10^3/\mu L$)	7.38 ± 3.1	7.33 ± 3.3	0.953
Lymc ($\times 10^3/\mu L$)	0.9 (0.5–1.3)	1.02 (0.77–1.27)	0.053
NLCR	6.8 (1.8–11.7)	6.7 (4.2–9.2)	0.184
LDH (IU/L)	436 (322–550)	239 (181–297)	***0.001***
D-dimer (mg/L)[&]	7.8 (2.1–35.2)	1.3 (0.6–3.9)	***< 0.001***
Ferritin (ng/mL)[&]	1268 (399–6110)	405 (157–1650)	***0.001***
IL-6 (pq/mL)[(13)&]	161 (36.2–2958)	24.5 (1.5–130)	***0.001***
CRP (mg/dL)[&]	11.8 (0.4–29.7)	0.9 (0.3–7.2)	***< 0.001***
Procalcitonin (ng/mL)[&]	0.27 (0.02–87)	0.1 (0.01–39)	***0.002***

Gucyetmez B, Atalan HK, Sertdemir I, Cakir U, Telci L; COVID-19 Study Group. Therapeutic plasma exchange in patients with COVID-19 pneumonia in intensive care unit: a retrospective study. Crit Care. 2020;24(1):492. Published 2020 Aug 8.

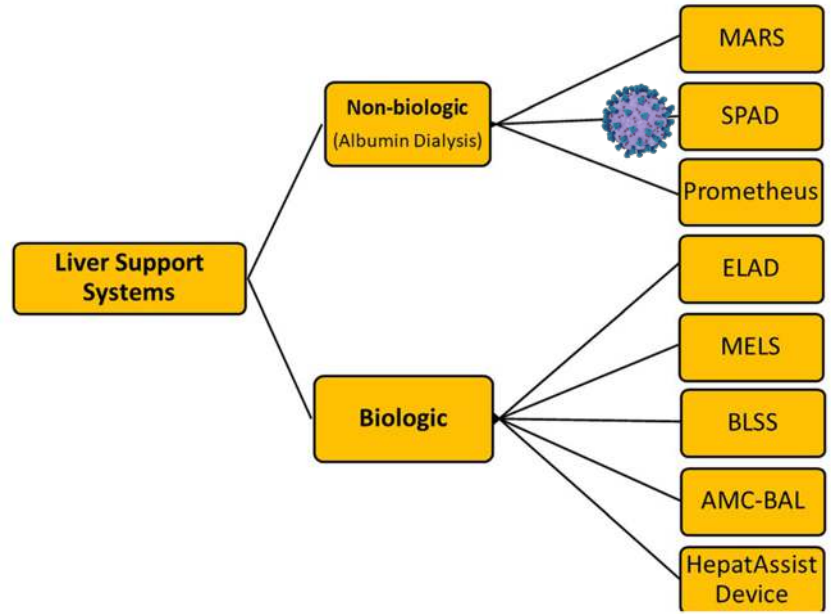
Chediak et al. Renal Replacement Therapy (2020) 6:15
https://doi.org/10.1186/s41100-020-00265-0

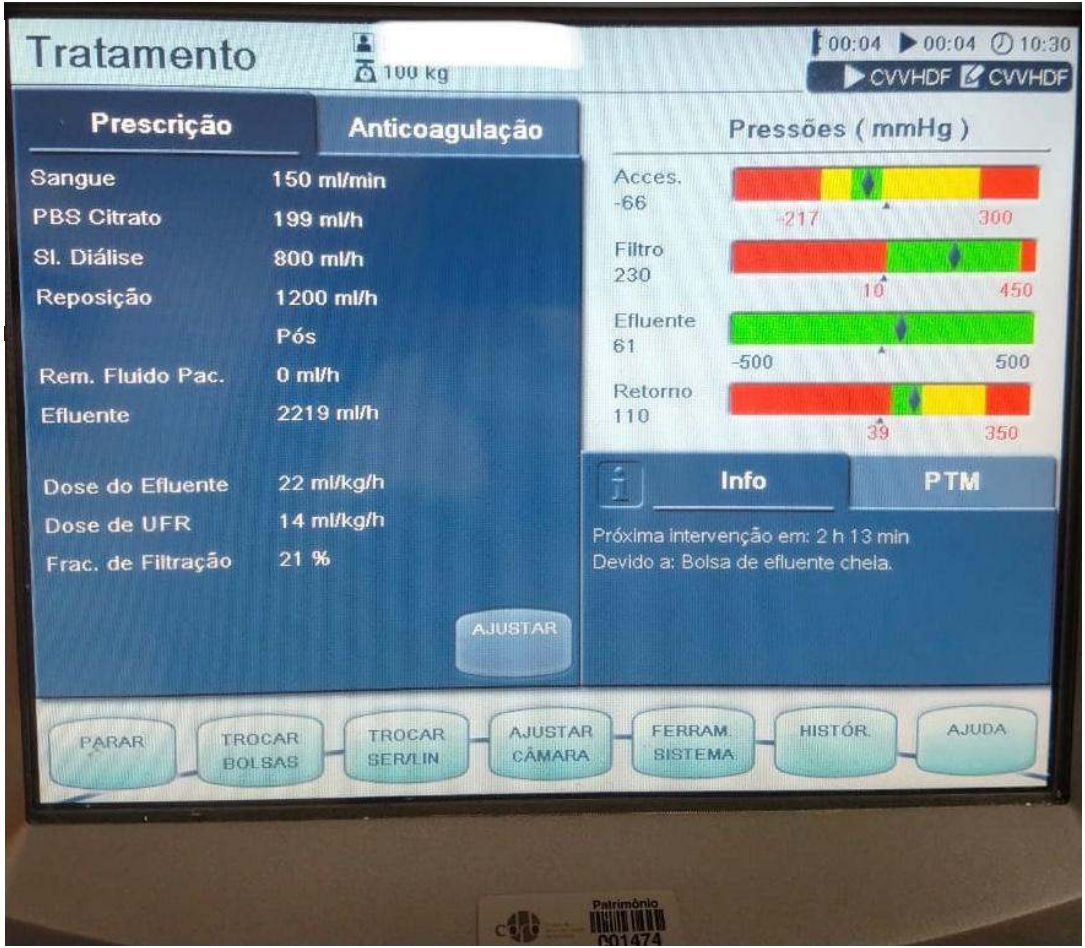
Renal Replacement Therapy

REVIEW Open Access

Bile cast nephropathy: when the kidneys turn yellow

Alissar El Chediak[1†], Khaled Janom[2†] and Sahar H. Koubar[3*]



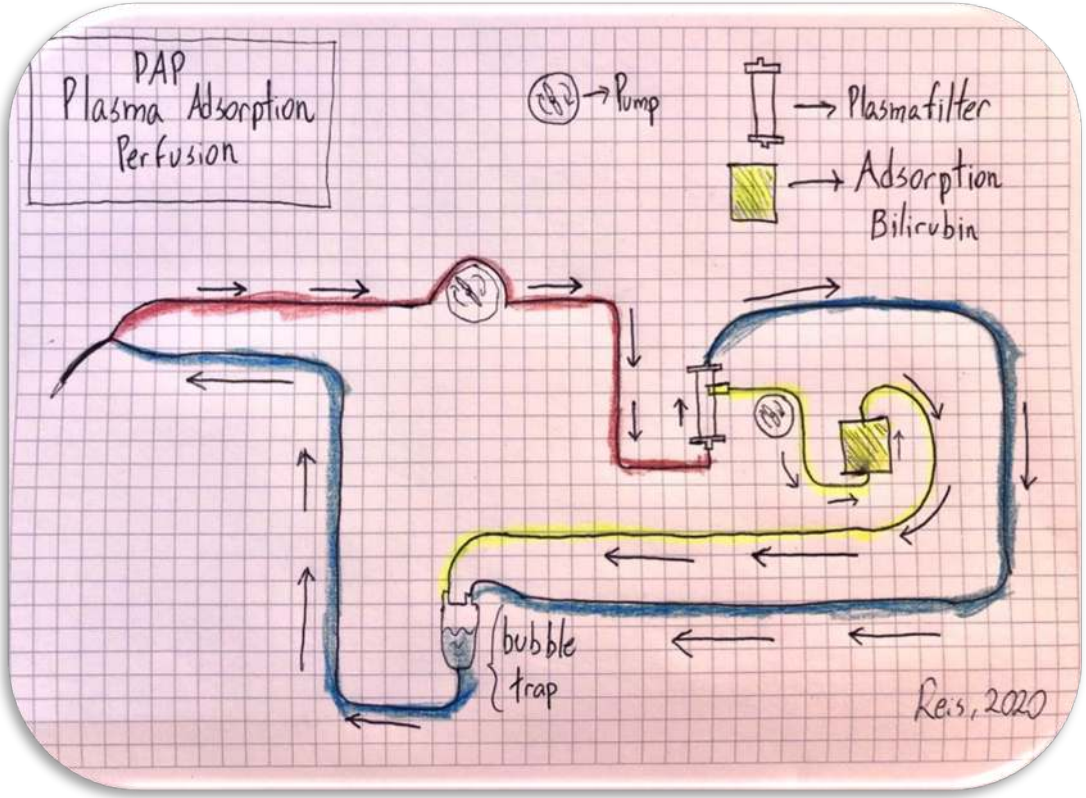


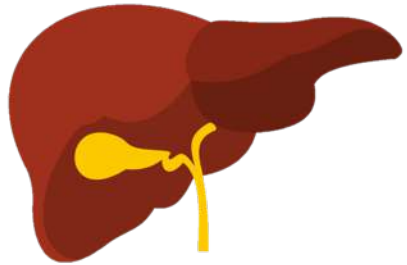
El Chediak, A., Janom, K, Koubar, S.H. Bile cast nephropathy: when the kidneys turn yellow. Ren Replace Ther 6, 15 (2020).

SINGLE-PASS ALBUMIN DIALYSIS

-Schmuck RB et al. Single Pass Albumin Dialysis-A Dose-Finding Study to Define Optimal Albumin Concentration and Dialysate Flow. Artif Organs. 2017 Feb;41(2):153-161
-Sponholz C et al. Molecular adsorbent recirculating system and single-pass albumin dialysis in liver failure--a prospective, randomised crossover study. Crit Care. 2016;20:2. Published 2016 Jan 4.

PLASMA ADSORPTION PERFUSION





1.Viggiano D, de Pascale E, Marinelli G, Pluvio C. A comparison among three different apheretic techniques for treatment of hyperbilirubinemia. J Artif Organs. 2018 Mar;21(1):110-116.
2. Donati G. Detoxification of bilirubin and bile acids with intermittent coupled plasmafiltration and adsorption in liver failure (HERCOLE study). J Nephrol. 2020 Jul 24.

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