Case of the Week Compendium

2015 Through March 2017
Combination ECMO and cytokine adsorption therapy for severe sepsis with cardiogenic shock and ARDS

Lees N, Rosenberg A, Popov A, Hurtado-Doce A, Jones J, Marczin N, Simon A  
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A 33-year-old previously fit female, 5 months postpartum, presented with shock, ARDS, metabolic acidosis and neutropenia as well as a severely impaired, non-dilated left ventricle. Treatment for community-acquired pneumonia was initiated including mechanical ventilation and significant vasopressor support. Venoarterial ECMO was started due to respiratory and cardiac failure, lactic acidosis and worsening organ function. Additionally, CytoSorb was added to the hemofilter circuit and antibiotics were administered. Treatment resulted in improved oxygenation, gradual resolution of lactic acidosis and most notably withdrawal of vasopressor support within 12 hours. The patient fully recovered and was asymptomatic two months later. This case demonstrates the novel and successful use of ECMO and cytokine removal in severe S. aureus sepsis with ARDS and cardiomyopathy and adds to the evidence showing cytokine adsorption as a compelling adjuvant therapy in severe sepsis.

**Case presentation**
- 33-year-old previously fit female, 5 mo postpartum, with four-day history of flu-like symptoms, breathlessness, delirium, chest and abdominal pains
- Condition: pyrexial, tachypneic and shocked, with ARDS (Murray score 3.7), metabolic acidosis (pH 7.1) and neutropenia
- Transthoracic echocardiography showed severely impaired, nondilated left ventricle (EF <15 %) and normal right ventricle
- Initiation of treatment for community-acquired pneumonia including mechanical ventilation and significant vasopressor support (NE 1-1.5 µg/kg/min, vasopressin 0.04 U/h, dobutamine)
- Transfer to specialized center for consideration of extracorporeal life support
- Start of venoarterial ECMO (percutaneous femoral cannulation) within 5 hrs of arrival due to respiratory and cardiac failure, rising lactate and worsening organ function
- Staphylococcus aureus and H1N1 Influenza A were isolated later

**Treatment**
- CytoSorb in combination with Prismaflex® (Gambro, Sweden)
- Treatment time: 24 h
- Anticoagulation: unfractionated heparin

**Measurements**
- Oxygenation
- Lactic acidosis
- Vasopressor need

**Results**
- Improvement in oxygenation
- Gradual resolution of lactic acidosis
- Withdrawal of vasopressor support after 12 h
Patient Follow-Up
- LV function was normal by day 9 when ECMO was discontinued
- Discharge to the ward on day 30
- Review two months later was asymptomatic

CONCLUSIONS
- Next to improvement of oxygenation and resolution of lactic acidosis, rapid weaning of vasopressors was the most notable clinical effect associated with CytoSorb therapy
- Treatment demonstrates the novel and successful use of ECMO and cytokine removal in severe S.aureus sepsis with ARDS and cardiomyopathy
- This case adds to the evidence showing cytokine adsorption as a compelling adjuvant therapy in severe sepsis
Case study of 8 patients with multiple organ failure treated additionally with CytoSorbents haemadsorption as adjunctive therapy in septic shock and severe SIRS in cardiac failure

Kogelmann K, Drüner M, Jarczak D
Department of Anaesthesiology, Hospital Emden, Germany Infection. 2015 Aug;43 Suppl 1:1-73. Abstract No. 58

In this case series the authors aimed to investigate the effectiveness of CytoSorb treatment in 8 patients with sepsis/SIRS and multiple organ failure. They found a pronounced decrease in catecholamine demand and a distinct tendency in decrease of blood lactate levels during the treatment period and within 72 hours after CytoSorb therapy. However, no significant changes for SOFA-Score nor SAPS II-Score were detected. Importantly, compared with overall survival of about 45 % in severe sepsis including septic shock the authors could find a survival of 62.5 % in these patients. Treatment with CytoSorb was safe and without any noticed side effects.

Patients, pre-treatment and indication for CytoSorb treatment
- Seven patients with septic multiple organ failure and one patient with severe SIRS and MOF in cardiac failure treated additionally with CytoSorb as adjunctive therapy in septic shock
- The infectious focus was abdominal (four patients) and pneumonic (three patients), one patient was without any infection
- Initial therapy of these patients followed the Surviving Sepsis guidelines and focused on adequate volume therapy, differentiated catecho- lamine therapy (administering norepinephrine to achieve a mean arterial pressure of 60 mmHg), administering antibiotics not later than 1 hour after detection of septic shock and lung-protective ventilation
- If there was no decline of catecholamine demand even after an additional corticoid treatment for 24 hours, CytoSorb therapy was initiated
- Indication for hemadsorption therapy further included: at least two-organ failure with APACHE-2 Score higher than 25, no decline in requirement of norepinephrine despite adequate conventional therapy over a 24 hours period as well as the need for renal replacement therapy

Treatment
- Duration of therapy with CytoSorb was predefined to be between 24 and 72 hours
- Adsorber was changed every 24 hours

Measurements
- Patient characteristics: sex, age
- APACHE-2 score, ventilator days, length of stay (ICU and in-hospital) and survival
- Before, during and after CytoSorb treatment
- – SAPS II-Score, SOFA-Score, MAP, requirement of norepinephrine, blood lactate level
- Demand of norepinephrine (μg/h vs. mmHg MAP) during therapy

Results
- Five patients were treated over a 72-h period, three patients for 48 h
- Only marginal differences in SAPS II and SOFA- Score:
- – SAPS II-Score at start 51.1 ± 11.74, at the end: 38.6 ± 9.7
- – SOFA-Score at start 11.1 ± 2.85, at the end 9.75 ± 2.2
- Slightly decreased blood lactate [mg/dl]
- – At start 29.2 ± 17.2, at the end: 13.9 ± 7.3
- Huge impact on need for catecholamines with respect to the demand of norepinephrine [μg/h] vs. the thereby achieved MAP [mmHg]
- – At start: 52.7 ± 26.9, at the end: 3.6 ± 4.7 [μg/h * mmHg]
- Compared with overall expected survival of about 45 % in severe sepsis including septic shock the authors could find a survival of 62.5 % in these patients
CONCLUSIONS

- Indication for CytoSorb therapy in this case series is comparable to former indication
- for activated recombinant human Protein C (drotegocin alfa activated): at least 2-organ failure with APACHE-2 score higher than 25, no decline in requirement of norepinephrine despite adequate conventional therapy over a 24 hours period
- Treatment with CytoSorb in these 8 patients was safe and without any noticed side effects
- The major effect seen was a pronounced decrease in catecholamine demand
- Compared with overall expected survival of about 45 % in severe sepsis including septic shock the authors could find a survival of 62.5 % in these patients
- Whether other patients could profit from this adjunctive treatment is uncertain and should be investigated
Intermittent use of cytokine adsorption in combination with CRRT in a patient with necrotising pancreatitis, septic shock and MOF

Emmerich M, Zietlow S, Tiesmeier J

This case study reports on a 60-year-old female patient with septic shock and MOF after cholecystectomy which was complicated by massive aspiration and necrotizing pancreatitis. On admission to ITU, the patient was in respiratory and acute renal failure and exhibited high needs for vasopressors and fluids. Lung-protective ventilation and hemodynamic stabilization, antibiotic therapy and CRRT plus Cytosorb were started in the further course. During the first 48 h of hemoadsorption, norepinephrine requirements decreased markedly. During the second use of Cytosorb norepinephrine infusion could be stopped after 40 h. CRRT was stopped 11 days after the second CytoSorb treatment and two days later the patient was successfully weaned from ventilation. The authors conclude that they could successfully use intermittent cytokine hemoadsorption to manage a patient with recurrent septic shock, necrotising pancreatitis and MOF. Supplementing the standard treatment for sepsis with two applications of hemoadsorption facilitated rapid hemodynamic stabilization. Cytosorb was easy to use and no adverse effects were observed.

Case presentation
- A 60-year-old female patient with septic shock and MOF post-cholecystectomy complicated by massive aspiration during emergency gastroscopy and necrotising pancreatitis requiring necrosectomy
- On admission to ITU, the patient was in respiratory and acute renal failure with high needs for vasopressors and fluids
- Following initial stabilization, colonic perforation and renewed septic shock occurred on day 13 post-operation, necessitating colectomy and further necrosectomy on day 14
- Lung-protective ventilation and hemodynamic stabilization using nuanced fluid and norepinephrine therapy with advanced hemodynamic monitoring
- Antibiotic therapy was initiated with meropenem and linezolid administered in dosages adopted to CRRT
- CRRT (CiCa-CVVHD) was started on day 2 post-operation and combined with CytoSorb

Treatment
- 1st CytoSorb treatment beginning on the second post-operative day for 48 hours
- 2nd CytoSorb treatment from day 13 post-operation for 96 hours

Measurements
- Need for norepinephrine

Results
- During the first treatment, norepinephrine requirement decreased from 0.13 to 0.00 μg/kg/min
- During the second treatment the initial norepinephrine need was 0.13 μg/kg/min which rose to a maximum of 0.43 μg/kg/min 12 h post-operatively
- However, the infusion could be stopped after 40 h
Patient Follow-Up
- The general condition of the patient improved dramatically despite further multiple operations for intra-abdominal bleeds, necrosis and wound healing impairment
- CRRT was stopped 11 days after the second treatment
- Two days later the patient was successfully weaned from ventilation

CONCLUSIONS
- Intermittent cytokine hemoadsorption could be successfully used to manage a patient with recurrent septic shock, necrotizing pancreatitis and MOF
- Supplementing the standard treatment for sepsis with two applications of hemoadsorption facilitated rapid hemodynamic stabilization
- Cytosorb was easy to use and showed no adverse effects
CytoSorb, a novel therapeutic approach for patients with septic shock: a case report

Department of Anaesthesiology and Intensive Care, Hospital Guestrow, Germany Int J Artif Organs. 2015 Sep 18;38(8):461-4.

This case study reports on a 72-year-old male patient with periodically recurring infectious episodes who was admitted with the suspicion of urosepsis. In the following hours his hemodynamic situation deteriorated markedly, exhibiting respiratory-metabolic acidosis, elevated inflammatory marker plasma levels, a severely disturbed coagulation, increased retention parameters, liver dysfunction, and confirmation of bacteria and leukocytes in urine. After admission to the ICU in a state of septic shock the patient received renal support with additional hemoadsorption using CytoSorb. Three CytoSorb sessions were run during the following days. The first and consecutive second session resulted in a reduction of procalcitonin, C-reactive protein and bilirubin and a markedly reduced need for vasopressors while hemodynamics improved significantly (i.e. cardiac index, extravascular lung water). Due to a recurring inflammatory “second hit” episode, another session with CytoSorb was run, resulting in a marked decrease in leukocytosis and liver (dys)function parameters. The rapid hemodynamic stabilization with reduction of vasopressor needs within hours and reduction of the capillary leakage as well as a quick reduction in infection markers were the main conclusions drawn from the use of CytoSorb in this patient. Additionally, treatment appeared to be safe and was well tolerated.

Case presentation
• 72-year-old male patient was admitted with suspicion of urosepsis
• Condition: progressing hemodynamic instability, elevated inflammatory marker plasma levels, severely disturbed coagulation, increased retention parameters, liver dysfunction, as well as a proof of bacteria and leucocytes in the patients’ urine
• Upon take over to ICU, patient was in septic shock with increasing need for fluids + vasopressors
• Due to a further increase of retention parameters and decreasing spontaneous diuresis the patient received continuous renal replacement therapy
• Ultrafiltration was performed to counteract massive volume overload and an increase of extravascular lung water
• As inflammatory markers remained high, the decision was made to additionally install a CytoSorb hemoadsorption column into the CVVHD circuit

Treatment
• Three CytoSorb sessions were run during the following days (1st session 24 hours, an immediately following 2nd session for 6 hours, 3rd session was 5 days later for 24 hours due to a recurring inflammatory second hit episode with increasing infection markers)
• Blood flow rate was kept at 180 ml/min and anticoagulation was achieved using heparin targeting a partial thromboplastin time (PTT) of 60 – 80 seconds controlled every 8 hours
• The CytoSorb adsorber was placed in a pre-dialyzer position

Measurements
• Laboratory: leucocytes, platelets, PCT, CRP, urea, creatinine, ALT, AST, bilirubin
• Clinical: Cardiac index, extravascular lung water index, noradrenaline dose, mean arterial pressure, fluid balance, urine output

Results
• Drop of PCT, C-reactive protein and bilirubin
• MAP stabilized and the need for norepinephrine could be reduced from 0.8 down to 0.13 μg/kg*min and was tapered out 48 hours after termination of the second treatment
• Dobutamine infusion (10 mg/h) could be stopped straight after the second treatment
• Hemodynamics improved significantly with a cardiac index increasing from 3.22 before the first to 4.5 l/min/m2 after the second treatment while extravascular lung water improved from 18.5 to 7.8 ml/kg in the course of the two treatments
• Albumin levels measured before and during both CytoSorb treatments did not change
• No adaptation of antibiotic dosage (daptomycin, clarithromycin and ceftazidim) at any time
Patient Follow-Up

- 3rd CytoSorb session resulted in a marked decrease of leukocytosis, CRP, and liver dysfunction parameters (ALT, AST, bilirubin).
- After regaining clinical stability the patient was transferred to the University Hospital of Greifswald (Germany) due to more advanced diagnostic testing methods for the yet not accomplished focus search and because of their experience in the use of CytoSorb hemoadsorption, in case the patient should develop further complications.
- Diagnostic testing revealed a spondylodiscitis and the focus was surgically eradicated.
- Probably due to the long previous antimicrobial therapy, no underlying germ could be detected.
- During the next days, organ functions and inflammatory status improved further, accompanied by a considerable improvement of the patients' general condition.
- After discharge, the patient showed no further infectious episodes in the follow-up period.

CONCLUSIONS

- In this patient CytoSorb therapy appeared to contribute to regain control over the patients' inflammatory response.
- Treatment appeared to be safe and was well tolerated.
- Main effects of CytoSorb: rapid hemodynamic stabilization with reduction of vasopressor needs within hours and reduction of the capillary leakage as well as a quick reduction of infection markers.
- Further studies are necessary to elucidate to what extent these favorable consequences are attributable to the adsorber itself.
Application of CytoSorb in a case of infection-associated rhabdomyolysis

Sven Suefke, Friedhelm Sayk, Martin Nitschke, University Lübeck

This case study reports on a 55-year-old patient with history of arterial hypertension who was admitted with complaints of dyspnea and symptoms of respiratory infection.

Case presentation

- Patient developed fulminant manifest pneumogenic sepsis and acute respiratory distress syndrome (ARDS) with massive requirements for fluids and catecholamines for hemodynamic stabilization
- Drastically increased plasma concentrations of myoglobin and creatine kinase on top of his inflammatory response, indicative of massive infection-associated rhabdomyolysis
- Generalized compartment syndrome due to fluid overloading, elevated creatinine levels and acute liver injury as evidenced by hyperbilirubinemia.
- For treatment of his acute kidney injury grade III (crush kidney) and for negative fluid balancing, renal replacement therapy was initiated using a Genius device with an AV600S filter
- To lower inflammatory mediator and myoglobin levels, CytoSorb was additionally installed

Treatment

- Four consecutive sessions were run over periods of 20 hours each, separated from one another by a pause interval of 4 hours.
- Blood flow rates were 150 ml/min
- Anticoagulation was achieved using citrate.
- The CytoSorb adsorber was placed in pre-dialyzer position.

Measurements

- Laboratory: Myoglobin, Creatine kinase, C-reactive protein, IL-6, Procalcitonin, Creatinine, ALT, AST, Bilirubin, Leucocytes, Thrombocytes, Hct, Hb, Albumin, Glucose, Na/K
- Clinical: Urine output

Results

- During the course of the treatment, plasma concentrations of IL-6, procalcitonin, myoglobin and creatine kinase decreased significantly
- Levels of leucocytes, thrombocytes, alanine aminotransferase, and aspartate aminotransferase normalized over the 4 consecutive treatments
- The clinical situation improved considerably including improvement of the patient’s respiratory situation and liver function
- Kidney function did not improve
- The course of hematocrit, Hb and platelet count provided no evidence for a potential lack of hemo- or biocompatibility of the CytoSorb treatment
- Antibiotic dosages did not have to be adjusted at any time
Patient Follow-Up

- Kidney function remained impaired after a total of 5 days on CytoSorb
- Patient was discharged at day 13 with ongoing renal failure and need for renal replacement therapy
- Two days after the last treatment with CytoSorb the patient could be extubated without further complications
- On Day 27, the patient was transferred to a respiratory weaning unit where the patient was subsequently successfully weaned off mechanical ventilation, with a discontinuation of CRRT and the recovery of renal function

CONCLUSIONS

- In this patient, the application of CytoSorb resulted in a significant reduction of cytokines (i.e. IL-6) but also had an important additive effect on myoglobin removal
- The effects seen in this patient are a sum of both adsorption techniques used (CVVH and CytoSorb)
- It remains speculative to what extent the effects seen can be ascribed to the application of the Cytosorb adsorber and therefore needs to be investigated in future randomized controlled trials
CytoSorb in a case of ARDS and multiple organ failure

Karl Träger, University Hospital Ulm

This case study reports on a 45 year old male patient who was admitted to hospital with small bowel obstruction due to torsion being immediately scheduled for surgical intervention.

Case presentation
- At anesthesia induction the patient aspirated and immediately underwent bronchoscopy.
- Laparotomy was performed and decompression of the small bowel was achieved.
- During operation the patient developed severe respiratory failure with indication for installation of a veno-venous ECMO.
- On ICU the patient developed severe ARDS, alveolar edema, systemic vasoplegia, marked capillary leakage, leucocytopenia and acute kidney injury grade 3 with indication for CRRT.
- Further treatment included bronchoscopy, veno-arterial ECMO, protective ventilation, kinetic positioning and application of the sepsis bundle.
- Due to a massive increase in markers of inflammation Cytosorb was added to the circuit.

Treatment
- Cytosorb® was used in conjunction with CVVHD added in pre-dialyzer position of the CRRT machine (Multifiltrate).
- Three treatments were consecutively performed for 85 hours in total (20+35+29 h).
- Blood flow rate between 100-140 ml/min.
- Regional anti-coagulation was achieved using a citrate-based protocol.

Measurements
- Course of IL-6 and IL-8 throughout the three treatments.
- Need for norepinephrine throughout the treatment period.
- Fluid balance during the three consecutive CytoSorb treatments.

Results
- Pronounced decrease in the concentrations of IL-6 and IL-8 continuing to decrease further in the following days.
- Patient stabilized hemodynamically and the need for norepinephrine was significantly reduced.
- Respiratory function improved during the treatment course, with a disappearance of any signs of alveolar exudation.
- Severity of capillary leakage as demonstrated by daily fluid needs and daily fluid balance became less apparent.
- CytoSorb treatment was safe and well-tolerated with no device related adverse events, and easy to implement as part of the CVVH circuit.
Patient Follow-Up

- At postoperative Day 12, therapy was started with methylprednisolone, in order to inhibit fibroproliferation in the lung and risk of fibrosis during ARDS
- A percutaneous tracheostomy was performed on Day 13
- By post-operative Day 18, the patient's respiratory function, along with gas exchange and lung mechanics, on mechanical ventilation had sufficiently improved such that VA-ECMO was discontinued
- CRRT had to be continued for a period of 20 days and could then be stopped after sufficient recovery of renal function

CONCLUSIONS

- Stabilization and successful treatment of a complicated pulmonary aspiration post-surgical patient with septic shock and polymicrobial infection, severe exudative ARDS, renal failure, and a severe SIRS response with pronounced hypercytokinemia
- Control over the patient’s initial hyper-inflammatory response was a key element in helping clinically stabilize the patient, allowing for organ recovery, and ultimately survival
- More randomized controlled studies using CytoSorb in critically-ill patients will help to establish the true benefit of the therapy
CytoSorb in a case of postoperative sepsis in a patient with necrotizing pancreatitis

Lutz Badura, Hospital Ellenburg

This case study reports on a 65-year-old female patient with underlying cholelithiasis undergoing a surgical procedure for severe necrotizing pancreatitis.

Case presentation
- Postoperatively progressing demand for catecholamines, and signs for multiple organ failure (lung, circulatory, kidney, gut)
- Sharp increase of PCT and CRP

Treatment
- Three consecutive CytoSorb treatment sessions of 23 hours each over a total period of 72 hours, separated from one another by a pause interval of 1 hours
- CytoSorb was used in conjunction with CRRT (machine Baxter BM11a/BM14) run in CVVHF mode
- Blood flow rate: 120 ml/min
- Anticoagulation: citrate
- CytoSorb adsorber position: pre-hemofilter

Measurements
- IL-6, PCT, CRP
- Demand for catecholamines
- Renal function

Results
- Treatment resulted a stabilization of the hemodynamic condition with decreased need for catecholamines
- Declining plasma levels of markers of infection and inflammation
- Marked improvement of renal function with beginning diuresis already during the treatment

Patient Follow-Up
- Despite regular lavage in the following days and an initial control of the systemic, inflammatory situation the patient suffered a relapse with multiple organ failure in the further course and died

CONCLUSIONS

- In this patient, treatment with CytoSorb resulted in a significant stabilization of hemodynamics with declining needs for catecholamines and improving organ functions especially of the kidney
- Handling of the absorber was easy and intuitive
CytoSorb in a case of necrotizing fasciitis and septic shock

Dr. Radovan Novak, Hospital Zittau

This case study reports on a 19-year-old male, who was taken to hospital by emergency ambulance with an erysipelas on his right hand and signs of systemic inflammation (fever, hypotonic, tachycardic and somnolent).

Case presentation
- Suspected necrotizing tendovaginitis/fasciitis with later proof of beta-hemolytic streptococci
- Immediate initiation of antibiotic therapy with imipenem, PCT plasma levels grossly elevated with >500 ng/ml
- In the further course beginning of renal failure, hemodynamic instability and shock
- Shortly thereafter necessity for mechanical ventilation
- On the same day surgical wound revision with extensive debridement of skin and subcutaneous tissue
- After surgery, very high and further rising catecholamine dosage required
- Initiation of CRRT due to onset of oliguria
- Indication for CytoSorb: existing access through CRRT, high catecholamine needs, refractory to standard treatment

Treatment
- Two CytoSorb sessions for 6 and 25 hours separated by a pause interval of 8 hours
- Premature stop of the first treatment after 6 hours due to a thrombus in Sheldon catheter
- Confirmed diagnosis of HIT II after prior drop of platelets
- Switch from heparin to argatroban for the second treatment due to HIT II diagnosis
- CytoSorb was run in combination with CRRT (Multifiltrate) in CVVH mode
- Blood flow rate: 150 ml / min, pre-hemofilter position of CytoSorb

Measurements
- IL-6, PCT, CRP, leucocytes
- Catecholamine dosage
- Renal function
- PTT during argatroban anticoagulation
- Hemodynamic variables via PICCO: CI, SVRI, GEDI and ELWI

Results
- Treatment resulted in hemodynamic stabilization of the patient with a significant reduction of catecholamines already during the first 6 hour treatment, and a drop to 10% of the initial dosage after the second CytoSorb session
- Reduction of PCT and other inflammatory parameters during treatment
- Decline of IL-6 from 2300 pg/ml to 36 pg/ml during the course of the two treatments
- Improved renal function with return of spontaneous diuresis
Patient Follow-Up

- CRRT could be stopped after the second CytoSorb treatment
- Extubation of the patient four days after the second treatment under stable conditions
- Routine debridement and dressing changes in the following days

CONCLUSIONS

- In this patient, treatment with CytoSorb resulted in a significant stabilization of hemodynamics with declining needs for catecholamines and improved organ functions
- Due to the early stabilization of the patient amputation could probably be avoided
- Handling of the adsorber was simple and intuitive
- Hospital team was enthusiastic and impressed about the fast, positive course
CytoSorb in a case of caecum perforation and fecal 4-quadrant peritonitis

Friedrich Nestler, Hospital Erlabrunn

This case study reports on a 76-year-old male patient who underwent emergency laparotomy due to an acute abdomen after a previous total hip replacement surgery.

**Case presentation**
- Intraoperatively confirmed colon perforation with 4 quadrant fecal peritonitis
- On admission to ICU after preceding surgery the patient was in septic shock with need for high catecholamine doses and mechanical ventilation
- Due to concomitant onset of renal failure with highly elevated inflammatory and infection markers (leucocytes 18.3, PCT 14.2, IL-6 >5000, CRP 459), the patient was started on renal replacement therapy in combination with CytoSorb

**Treatment**
- Three consecutive CytoSorb treatment sessions of 24 hours each over a total period of 72 hours
- CytoSorb was used in conjunction with CRRT (Baxter BM11a/BM14) in CVVHF mode
- Blood flow rate: 140 ml/min
- Anticoagulation: citrate
- CytoSorb adsorber position: pre-hemofilter

**Measurements**
- IL-6, PCT, CRP, leucocytes
- Demand for catecholamines
- Renal function (diuresis, creatinine, urea)

**Results**
- Hemodynamic stabilization of the patient with significantly decreased needs for catecholamines
- Effective reduction of IL-6 levels down to 200 pg/ml after the last treatment
- Declining plasma levels of CRP and PCT during the three CytoSorb sessions
- Marked improvement of renal function with onset of spontaneous diuresis and decreasing retention parameters
Patient Follow-Up

- In the further course secondary wound infection with local abdominal wall infection, requiring intraabdominal lavage, debridement and ultimately secondary abdominal wall closure
- Delayed weaning, critical illness polyneuropathy
- Successful transfer of the patient to a neurologic rehabilitation unit in the further course

CONCLUSIONS

- Treatment with CytoSorb resulted in a significant stabilization of hemodynamics with declining needs for catecholamines, an effective reduction of inflammatory markers as well as a considerable improvement of kidney function
- Handling of the absorber was safe and easy after an initial training phase
CytoSorb in a case of pneumogenic septic shock and multiple organ failure

Dr. Markus Engel, Senior Consultant Medical ICU, Hospital Bogenhausen, Munich, Germany

This case study reports on a 53-year-old male patient with sepsis and acute kidney failure who was admitted to the hospital from an external clinic via emergency helicopter transport.

Case presentation

- Before admission patient already experienced ten days of flu infection with cough and phlegm and also diarrhea and vomiting in the last three days and began to develop a pronounced exanthema
- On admission on ICU the patient was in fulminant septic shock with need for high catecholamine doses and low oxygen saturation of 94% despite FiO2 of 1.0 and high airway pressures
- Sonography revealed fluid-filled bowel loops reflecting paralytic ileus and enlarged kidneys on both sides indicative for acute renal failure
- Extracorporeal lung replacement therapy was applied due to ventilation failure with global respiratory insufficiency and particular severe hypoxia
- Due to 5-organ failure due to the massive inflammatory reaction and a sustained therapy-refractory septic shock state adjunctive treatment with CytoSorb was started

Treatment

- Two CytoSorb treatment sessions over a total period of 48 hours
- CytoSorb was used in conjunction with CRRT (multiFiltrate, Fresenius Medical Care) in CVVHD mode
- Blood flow rate: 130 ml/min
- Anticoagulation: citrate
- Later on change to CVVHDF with heparin anticoagulation due to increasing liver failure
- CytoSorb adsorber position: pre-hemofilter

Measurements

- Demand for catecholamines
- Lactate

Results

- Hemodynamic stabilization of the patient with significantly decreased needs for catecholamines
- Effective reduction of lactate levels during the CytoSorb sessions
Patient Follow-Up

- In the further course diagnosis for toxic epidermolysis and suspected staphylococcal scaled skin syndrome
- Another 20 days later second septic episode with repeated usage of CytoSorb again resulting in rapid improvement of the hemodynamic situation
- After further stabilization surgical removal of necrotic tissue on extremities and upper limb with following local flap cosmetic surgery
- Termination of renal replacement therapy
- Finally, successful transfer of patient to a rehabilitation unit

CONCLUSIONS

- Treatment with CytoSorb resulted in significant stabilization of hemodynamics with declining needs for catecholamines and an effective reduction of lactate levels
- During the second septic episode again stabilization of the hemodynamic condition within a few hours during CytoSorb treatment
CytoSorb in a case of severe infection of an implantable cardioverter defibrillator (ICD) lead

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This case study reports on a 73-year-old female patient who was admitted to hospital with back pain due to severe degenerative spine manifestations and who deteriorated significantly in the further course.

**Case presentation**
- Development of septic shock with multiple organ failure (circulatory, renal, lung)
- Proof of Methicillin-Susceptible Staphylococcus aureus (MSSA)
- Excessively elevated inflammatory parameters (CRP, PCT, leucocytes)
- Excessively high demand for catecholamines (noradrenaline up to 2 µg/kg/min)
- Initiation of mechanical ventilation with high inspiratory pressures
- Severely impaired renal function with increased retention parameters and anuria with immediate initiation of citrate dialysis
- Due to sharp increase of inflammatory markers and progressive need for catecholamine, the patient was treated with CRRT in combination with CytoSorb

**Treatment**
- Three CytoSorb treatment sessions for three days with treatment time of 24-27 hours each
- CytoSorb was used in conjunction with citrate dialysis (Multifiltrate; Fresenius Medical Care) in CVVHD mode
- Blood flow rate: 180 ml/min
- Anticoagulation: citrate
- CytoSorb adsorber position: pre-hemofilter

**Measurements**
- Demand for catecholamines
- Renal function (creatinine, urea, excretion)
- Inflammatory parameters (CRP, PCT, leucocytes)
- PICCO measurements – volume- and hemodynamic parameters, Extravascular lung water (ELWI)

**Results**
- Hemodynamic stabilization of the patient with significantly decreased needs for catecholamines
- Significantly declining renal retention parameters and reduction of inflammatory parameters during the CytoSorb sessions
- Reduction of capillary leakage including ELWI under treatment
Patient Follow-Up
- In the further course an infection of an implantable cardioverter defibrillator (ICD) lead with resulting endocarditis was confirmed as focus
- Focus was eradicated by surgical removal of the ICD and its lead
- After further hemodynamic stabilization catecholamines could be completely tapered out
- Termination of renal replacement therapy
- Persisting but decreasing septic encephalopathy

CONCLUSIONS
- Combined treatment of CRRT with CytoSorb resulted in significant stabilization of hemodynamics with declining needs for catecholamines and an improvement of capillary leakage and the inflammatory situation
- Handling of the adsorber was easy and intuitive
CytoSorb in a case of fulminant toxic shock syndrome from β-hemolytic streptococcus group A with severe circulatory shock and multiple organ failure

Dr. Markus Engel, Senior Consultant Medical ICU, Hospital Bogenhausen, Munich, Germany

This case study reports on a 46-year-old female patient who was admitted to emergency department with beginning septic shock.

Case presentation
- 14 days prior in proctological treatment for rectal herpesvirus infection and initiation of therapy with acyclovir
- Since 3 days painful swelling of lymph nodes in the groin and for the last 2 days chills followed by abdominal pain, diarrhea and vomiting
- Suspecting toxic shock syndrome, the contraceptive coil was removed and patient was started on broad-spectrum antibiotic therapy
- Venous blood gas analysis exhibited metabolic acidosis (pH 7.26, BE -9, 2mmol/l, lactate 8.22 mmol/l)
- On admission to ICU patient was awake and fully oriented, however despite massive fluid replacement (+8000 ml until transfer) and noradrenaline administration persistent hypotension (70 mmHg systolic) and tachycardia
- In the following hours development of fulminant shock syndrome with massive volume requirement, highest needs for catecholamines (noradrenaline up to 4.5 mg/h), respiratory insufficiency, oliguria/anuria, capillary leakage and pronounced disseminated intravascular coagulation (DIC)
- Explorative laparotomy with unclear abdomen and further deterioration of clinical status gave no indication on the septic focus
- Due to multiple organ failure (4) because of the massive inflammatory reaction as well as a persisting hitherto therapy-refractory septic shock, CRRT was started in combination with CytoSorb therapy

Treatment
- One CytoSorb treatment sessions for a total period of 24 hours
- CytoSorb was used in conjunction with CRRT (multiFiltrate, Fresenius Medical Care) in CVVHD mode
- Blood flow rate: 100 ml/min
- Anticoagulation: citrate
- CytoSorb adsorber position: pre-hemofilter

Measurements
- Demand for catecholamines
- Lactate

Results
- Hemodynamic stabilization of the patient with significantly decreased needs for catecholamines
- Effective reduction of lactate levels during the CytoSorb sessions
Patient Follow-Up

- Diagnosis of toxic shock syndrome with proof of β-hemolytic streptococcus on removed coil
- Despite hemodynamic stabilization severe microcirculatory failure with necrosis on hands and feet on both sides
- In the further course short uroseptic period with urine congestion of unclear etiology (Double J placement)
- Necessity for amputation of the right hand and lower legs on both sides
- Finally successful transfer to rehabilitation unit

CONCLUSIONS

- Treatment with CytoSorb resulted in a significant stabilization of hemodynamics and declining needs for catecholamines as well as an effective reduction of lactate plasma levels
CytoSorb in a case of severe burn injury (60% BSA) and sepsis

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This case study reports on a 51-year-old patient who was admitted to hospital with severe burn injury (60% BSA) and inhalation trauma due to an explosion accident.

Case presentation
- Instantaneous initial treatment with bath therapy, tracheotomy and escharotomy on both legs due to circular burns grade 3
- From day two acute kidney failure with indication for dialysis
- In the further course daily routine dressing changes, in total seven operations with debridement and split skin grafts
- 27 days after admission development of severe sepsis
- Proven microbial species: Enterococcus faecium, Escherichia coli, Staphylococcus epidermidis, Aspergillus fumigatus (tracheal secretion negative)
- Antibiotic therapy with meronem, voriconazol, linezolid
- High demand for catecholamines (noradrenaline 3.6mg/h, vasopressin 2.4IE/h, dobutamine 45mg/h)
- Mechanical ventilation: high peak inspiratory pressures, high FiO2
- Severely impaired renal function with increased retention parameters and anuria
- Massive myoglobinemia (15696 µg/l) and significantly elevated inflammatory parameters (CRP 275 mg/l, PCT 28.75 µg/l, WBC 15500/µl)
- Due to the progressive need for catecholamine and massive myoglobinemia a CytoSorb adsorber was added into the CRRT circuit

Treatment
- Three CytoSorb treatment sessions for three days with treatment time of 24 hours each
- CytoSorb was used in conjunction with CRRT (Prismaflex, Gambro) in CVVHD mode
- Blood flow rate: 200 ml/min
- Anticoagulation: heparin
- CytoSorb adsorber position: post-hemofilter

Measurements
- Demand for catecholamines
- Renal function (creatinine, urea, excretion)
- Myoglobin
- Inflammatory parameters (CRP, PCT, WBC)

Results
- Hemodynamic stabilization of the patient with significantly decreased needs for catecholamines (noradrenaline 0.6mg/h, dobutamine 5mg/h )
- Significantly declining renal retention parameters and reduction of inflammatory parameters (CRP 237 mg/l, PCT 10.78 µg/l, WBC 9.900/µl)
- Reduction of myoglobin plasma levels to 7944 µg/l during the three CytoSorb sessions
Patient Follow-Up

- In the further course continuation of intensive care treatment
- Termination of renal replacement therapy after 70 treatment days (43 days after initial CytoSorb treatment)
- Patient stable, free of mechanical ventilation and capable for rehab
- Finally, successful transfer of patient to a rehabilitation unit

CONCLUSIONS

- Treatment with CytoSorb resulted in significant stabilization of hemodynamics with declining needs for catecholamines as well as control of the septic episode and myoglobinemia
- CytoSorb was safe and easy to apply
Use of CytoSorb in a case of severe post reanimation shock

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St. Franziskus-Hospital Mönchengladbach, Germany, Department of Cardiology and Intensive Care Medicine

Case presentation
- Patient was admitted to ICU with mechanical ventilation and moderate demand for catecholamines (noradrenaline 0.5 mg/h)
- Instantaneous cardiac catheter examination with exclusion of coronary heart disease
- Immediate hypothermia treatment for 24 hours at 34°C
- Thereafter warming up at 0.25°C/hour until target temperature of 36°C
- PICCO-guided catecholamine and volume therapy due to ensuing hemodynamic instability and progressively increasing needs for catecholamines
- Development of oliguric acute kidney failure and a shock pancreas with considerably elevated lipase plasma levels (6000 U/l)
- Due to the acute kidney failure and the progressive need for catecholamines (NOR 10 mg/h, dobutamine 50 mg/h) a CytoSorb adsorber was installed in combination with CVVHD

Treatment
- One CytoSorb treatment for 48 hours
- CytoSorb was used in conjunction with CRRT (Multifiltrate, Fresenius Medical Care) in CVVHD mode
- Blood flow rate: 150 ml/min
- Anticoagulation: heparin
- CytoSorb adsorber position: pre-hemofilter

Measurements
- Hemodynamic variables measured using PICCO (CI, SVRI, ITBVI)
- Demand for catecholamines
- Renal function (creatinine, urea, diuresis)
- Inflammatory parameters (CRP, PCT, WBC)

Results
- Hemodynamic stabilization (CI, SVRI, ITBVI) of the patient along with significantly decreased needs for catecholamines within 14 hours (noradrenaline 2 mg/h, dobutamine 30 mg/h)
- Significantly declining renal retention parameters under CVVHD
- Reduction of inflammatory parameters (CRP, WBC)
Patient Follow-Up

- In the further course development of a bilateral pneumonia necessitating installation of veno-venous ECMO for another 9 days
- Termination of renal replacement therapy 6 days after initial CytoSorb treatment
- Subsequent transfer to IMC and several days later to general ward
- Finally, implantation of an automatic cardioverter-defibrillator and successful transfer of patient to a rehabilitation unit

CONCLUSIONS

- Successful application of CytoSorb in a case of post-reanimation shock
- Treatment with CytoSorb resulted in significant stabilization of hemodynamics with declining needs for catecholamines within a few hours
- Application of CytoSorb was safe and easy
Use of CytoSorb in a case of severe ARDS after H1N1 infection and septic multiple organ failure

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This case study reports on a 48-year-old female patient presenting at the hospital with flu-like symptoms and whose respiratory situation deteriorated rapidly in the further course.

Case presentation

- Patient was admitted to ICU mechanically ventilated with severe ARDS and full-blown septic shock and multiple organ failure (pulmonary, hepatic, renal, circulatory)
- Virus diagnosis proved infection with H1N1 and subsequent antiviral therapy with Tamiflu
- Fast progression to circulatory failure
- Progressive global respiratory failure necessitating implantation of venovenous ECMO with subsequent change to veno-veno-arterial ECMO due to development of right heart failure
- Development of acute, anuric, dialysis-dependent kidney insufficiency with indication for renal replacement therapy
- Due to the fast progression to septic multiple organ failure with highly catecholamine-dependent circulatory insufficiency a CytoSorb adsorber was installed in combination with CVVHD
- Significantly elevated plasma levels of PCT at start of therapy (26 ng/ml)

Treatment

- Two CytoSorb treatments for 24 hours each
- CytoSorb was used in conjunction with CRRT (Multifiltrate, Fresenius Medical Care) in CVVHD mode
- Blood flow rate: 100 ml/min
- Anticoagulation: Argatroban (0.2 mcg/kg/min)
- CytoSorb adsorber position: pre-hemofilter

Measurements

- Demand for catecholamines
- Infection parameters (PCT)

Results

- Hemodynamic stabilization of the patient along with significantly decreased needs for catecholamines, vasopressors could be tapered out as early as 36 h after start of CytoSorb therapy
- Fast decrease of plasma PCT levels to 5.4 ng/ml after stop of CytoSorb therapy
Patient Follow-Up

- In the further course rapid improvement of the respiratory situation and stop of ECMO 7 days after cessation of CytoSorb therapy
- Termination of renal replacement therapy 7 days after the last CytoSorb treatment
- Due to a recurring pulmonary deterioration the ECMO therapy had to be initiated again on week after stop of the initial ECMO treatment
- Return to only One-Organ-failure (lung) in the context of severe influenza with ongoing clinical improvement

CONCLUSIONS

- Successful application of CytoSorb in a case of severe ARDS after H1N1 infection and septic multiple organ failure
- Overall rapid improvement of circulatory insufficiency within a few hours and reversal of multiple organ failure
- Also rapid reduction of PCT levels which was potentially favored by the application of CytoSorb in conjunction with causal sepsis therapy
- Application of CytoSorb was possible without problems even in first-time application
Use of CytoSorb in a case of toxic shock syndrome

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This case study reports on a 17-year-old male who reported to the pediatrician at a local rural hospital with complaints of pretibial pain in his right leg, after he accidentally cut his leg while in the fields a few days earlier.

Case presentation
- Diagnosis of a phlegmon with an abscess followed by surgical debridement with wound nettoyage with no clinical signs of subcutaneous emphysema or necrotising fasciitis
- Postoperatively the patient’s condition deteriorated and after admission to ICU he developed erythema, spreading from the right lower leg to the right upper leg, abdominal wall and the left leg, consistent with toxic shock syndrome
- Development of septic shock due to invasive S. aureus infection with respiratory failure, hemodynamic instability treated with vasopressors, hydrocortisone, antibiotic therapy
- Due disease severity, CRRT was initiated with a CytoSorb adsorber with the only goal to remove cytokines (despite absence of acute kidney injury and no need/indication for renal replacement therapy)

Treatment
- CytoSorb was used in conjunction with CRRT (Baxter HF 19 Aquamax)
- One treatment was performed for 24 hours in total
- Blood flow rate between 240 ml/min
- Regional anti-coagulation was achieved using a citrate-based protocol

Measurements
- Need for norepinephrine throughout the treatment period
- CRP, hemoglobin, Hct, MCV (fl), thrombocytes, leucocytes, INR, aPTT, Urea, Crea, Phosphate, Bilirubin, Gamma GT, Alkaline phosphatase, ALAT, ASAT, LDH, Creatine kinase, Albumin, Lactate, pCO2, pO2 HCO3-, Base excess, Saturation, SvO2, PaO2:FIO2 ratio

Results
- Within six hours after start of CytoSorb therapy, the erythema progression stopped and after 12 hours the need for vasopressors diminished
- After 24 hours, vital signs were: sinus tachycardia (112 beats/min), blood pressure 117/49 mmHg without vasopressors, no more fever
- The erythema diminished after a few hours and had disappeared after 24 hours
Patient Follow-Up

- After cessation of CytoSorb diuretics were started because of fluid overload
- Respiration improved, the ventilator support was diminished and the patient was extubated on day 5 after admission, within 72 hours of cessation of CRRT
- On day 6, patient was transferred back to the local hospital for further revalidation

CONCLUSIONS

- The progression of the erythema, together with that of the respiratory and circulatory failure, seemed to stop after six hours of CytoSorb therapy
- The reduction in the erythema after the start of CytoSorb was remarkable and the need for vasopressors stabilized and decreased within six hours after initiation
- In the authors opinion, the patient would have survived without CytoSorb, but they feel that his stay in the ICU might have been shortened by the CytoSorb adsorber
- Randomized controlled trials will have to be performed to find out whether the theoretical beneficial effects of CytoSorb are clinically relevant, as well as the possibilities of unwanted side effects
- Although the clinical value still has to be established, the first experiences with the CytoSorb adsorber are promising and justify further investigation
Septic shock secondary to β-hemolytic streptococcus-induced necrotizing fasciitis treated with a novel cytokine adsorption therapy

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This case study reports on a 60-year-old female with no pre-existing diseases except hypertension and hypothyroidism presented at the hospital with radius fracture of the right forearm after an accident.

Case presentation
• Immediate wound care was achieved by application of a plaster splint followed by operative osteosynthesis on the same day
• Swelling of the forearm expanding to the upper arm
• Patient collapsed and was transferred to ICU with diagnosis of septic shock
• Antibiosis and volume therapy were initiated while requirement for vasopressors drastically increased
• Development of oliguric acute renal failure and ARDS and commencement of mechanical ventilation
• Implementation of continuous veno-venous hemofiltration in combination with CytoSorb
• In the further course proof of infection with β-hemolytic streptococci

Treatment
• Three CytoSorb hemoperfusion sessions on the first day as well as on day 3 and 4 after ICU admission in combination with standard CVVHD
• Treatment time was 36 hours in the first and 17-18 hours in the two following procedures
• Blood flow rates 100 ml/min
• Regional citrate anticoagulation

Measurements
• Markers of inflammation, organ dysfunction and need for vasopressors
• Leucocytes, platelets, IL-6, cumulative urine output, creatinine

Results
• CytoSorb effectively and significantly reduced IL-6 levels
• After the first session, IL-6 plasma concentration decreased from 70000 to 39100 pg/ml (-44.3%). The final IL-6 level after the third session was 66 pg/ml
• CytoSorb treatment was paralleled by a significant decrease of vasopressor need
• Antibiotic therapy was conducted with Ampicillin and Fosfomycin, with no reported adaption of dosage during CytoSorb therapy
• The patient could be successfully stabilized until surgical control of the infectious source was achieved
Patient Follow-Up

- After the third CytoSorb treatment hemofiltration was continued without CytoSorb as the need for vasopressors was significantly decreased and IL-6 levels were back in a normal range
- Despite considerable reduction of IL-6 levels, amputation was inevitable
- The general condition improved and the patient could be extubated 4 days after the third CytoSorb treatment

CONCLUSIONS

- Treatment was safe and well-tolerated, without adverse events
- CytoSorb significantly reduced IL-6, a predictor of mortality in sepsis and surrogate for cytokine storm
- The patient could be successfully stabilized until surgical infectious source control was performed
- CytoSorb in combination with CVVHD and regional citrate anticoagulation could be run continuously for up to 36 h
- Hemoadsorption using CytoSorb seems to represent a promising approach for an effective and safe treatment of severe sepsis and septic shock.
First successful combination of ECMO with cytokine removal therapy in cardiogenic septic shock: A case report

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This case study reports on a 39-year-old patient presenting at a hospital with fulminant ARDS and cardiogenic septic shock.

Case presentation

- A 39 year old male with a history of dilated idiopathic cardiomyopathy (LV-EF 20 %) was scheduled for regular ambulatory check up in the hospital from 2006 to 2012
- Medical history included secondary pulmonary hypertension, mitral valve insufficiency grade II – III, chronic renal failure, hypothyroidism and nicotine- and anabolic abuse
- A dual-chamber implantable cardioverter- defibrillator (ICD) was implanted already in 2006 and the patient was planned for heart transplant as from January 2007
- In early January 2013 the patient had been at the HDZ Bad Oeynhausen for a 3-day routine check and presented one week later at an external hospital with complaints of dyspnea
- After a short period of primary non-invasive ventilation the patient drastically deteriorated, was intubated and further ventilated mechanically
- Subsequent chest X-ray confirmed massive bilateral infiltrates
- Within several hours the patient developed a fulminant ARDS and cardiogenic septic shock
- Implantation of a veno-arterial ECMO on site and transport back to HDZ
- Patient developed an acute renal failure on top of his chronic renal insufficiency making CVVH necessary while the need for vasopressors increased drastically
- Due to a global cardiac akinesia and high risk of intracardial thrombosis, decision was made for implantation of a left ventricular assist device (LVAD) in combination with a right ECMO (rECMO) in exchange for the va-ECMO
- Operation was carried out despite full-blown sepsis with poor post-operative clinical condition
- As last resort decision, a CytoSorb hemoadsorption device was installed into the CVVH circuit

Treatment

- CytoSorb was installed into the CVVH circuit (AK200; Gambro)
- Sessions were run on the first day as well as on day 2 and 4 after the operation over periods of 18 to 21 h each
- Blood flow rates were between 155 ml/min and 240 ml/min
- Anticoagulation was achieved using heparin, targeting a partial thromboplastin time (PTT) of 60 to 80, monitored every 4 h

Measurements

- Inflammatory markers (IL-6, CRP, PCT) as well as need for vasoactive substances (norepinephrine, epinephrine, vasopressin) were determined

Results

- With start of the CytoSorb therapy in combination with ECMO, inflammatory markers IL-6, procalcitonin, and CRP markedly decreased during treatment and continued to decrease further in the following days
- Also vasopressors could be reduced significantly and were stopped during (for norepinephrine and vasopressin) and shortly after (for epinephrine) the last treatment
- No negative effects on platelet count were observed
- During the entire treatment period (4 days in total) the patient received Linezolid, Meropenem, Moxifloxacin, Voriconazol and Acyclovir as boluses with no adaptation of dose at any time
**CONCLUSIONS**

- This is the first clinical case report in a patient treated with LVAD, rECMO, CVVH, and CytoSorb in a combined fashion
- The combination was practical, technically feasible and highly beneficial for the patient
- After commencement of CytoSorb treatment, the patient’s inflammatory status improved and vasopressor support could be reduced and tapered out
- No adverse or any device-related side effects were documented during or after the treatment
- Taken together, CytoSorb could be simply used in combination with ECMO, resulting in considerable benefits for the patient, thus representing a reasonable approach to improve survival in patients with several organ dysfunctions and the need for multiple organ supportive techniques
First report of cytokine removal using CytoSorb in severe noninfectious inflammatory syndrome after liver transplantation

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This case study reports on a 46-year-old man who underwent deceased donor liver transplantation (LT) for Hepatitis-B-Virus (HBV) and alcoholic cirrhosis.

Case presentation

- Postoperatively, the patient remained neurologically unresponsive, could not be extubated, and there was a massive increase in serum transaminases and bilirubin
- Hyperdynamic hemodynamic status with a high cardiac index (CI) and low systemic vascular resistance index (SVRI) requiring vasopressor support was noted immediately after surgery
- Laboratory results showed disseminated intravascular coagulopathy and one session of plasma exchange was performed for severe coagulopathy and cholestasis
- Acute graft dysfunction was diagnosed on the 1st postoperative day with emergency retransplantation (ABO incompatible) 36 hours after the first LT

Treatment

- CytoSorb was used in conjunction with CVVH during retransplantation for the entire duration of surgery (total treatment time of 7 hours) and on the first postoperative day with a treatment time of 12 hours
- CytoSorb was installed into the CVVH circuit (MultiFiltrate® using an Ultraflux® AV 600S hemofilter)
- Blood flow rates were 150 ml/min
- Anticoagulation was achieved using heparin

Measurements

- Cytokine levels were measured at the beginning of surgery (T1), after graft reperfusion (T2), at the end of surgery (T3) and before (T4) and after (T5) the second CytoSorb treatment
- Hemodynamic parameters, biochemical assays and vasopressor support were noted

Results

- During the first treatment proinflammatory cytokines IL-1b, TNF-a, IL-6 and IL-8 levels decreased, antiinflammatory cytokines IL-4, IL-13 were constant within the normal range, IL-10 and MCP-1 levels decreased 10-fold to about normal levels
- Improvement in hemodynamics with a stabilized MAP and a continuous decrease in vasopressor support (NE) during surgery (NE discontinued at the end of surgery)
- The use of CytoSorb during the second session was associated with an improvement in cardiac output and SVRI
- Lactate levels and central venous oxygen saturation (ScvO2) returned to normal values
- A decrease in platelet count was observed during both treatments (attributed to a multifactorial etiology: CVVH procedure, use of heparin, intraoperative blood loss, and possibly to the use of CytoSorb)
- The treatment was well tolerated with no obvious adverse effects
Patient Follow-Up
- Patient was extubated 12 hours after re-transplantation
- Liver function returned to normal within the next 5 days
- Discharge from the Post Anaesthesia Care Unit 7 days after retransplantation
- Discharge from hospital on the 35th postoperative day
- At the 4 month follow-up the patient was in good clinical state with normal liver function
- A normal liver function was also recorded at the 1-year follow-up

CONCLUSIONS
- 1st use of CytoSorb during CVVH in a patient undergoing re-transplantation with AB0 incompatible graft for Acute Graft Dysfunction
- The use of CytoSorb® was associated with an excellent outcome in terms of improved hemodynamic parameters, rebalancing proinflammatory and antiinflammatory cytokines, and patient survival to hospital discharge
- Observation suggests a shift from a SIRS state to a more compensated inflammatory response syndrome
- Hemoadsorption columns may represent an approach to bridge patients with acute liver failure or Acute Graft Dysfunction to liver transplantation
- A randomized controlled trial is needed to further evaluate efficacy and indications for hemoadsorption in patients with either acute liver failure or chronic liver disease in the perioperative period of LT, especially in patients with severe I-R injury
CytoSorb in postoperative septic shock after pylorus-preserving pancreaticoduodenectomy

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This case study reports on a 71-year-old male patient who presented at the hospital with painless icterus, reduced general condition and significant weight loss and who was later diagnosed for having pancreatic carcinoma.

Case presentation
- Two days after initial admission surgical pylorus-preserving pancreaticoduodenectomy (PPPD) with uncritical intraoperative course
- Postoperatively the patient developed fever exhibiting clinical signs of sepsis
- Diagnosis of a pancreatic fistula with subsequent reoperation
- After reoperation the patient was in critical condition, septic toxic shock, high doses of catecholamines, PCT 21 ng/ml, IL-6 >5000 pg/ml
- Severely impaired renal function with increased retention parameters and anuria with immediate initiation of citrate dialysis (CVVHD)
- Due to sharp increase of inflammatory markers and progressive need for catecholamine, the patient was treated with CRRT in combination with CytoSorb

Treatment
- Two CytoSorb treatment sessions for 24 hours each
- CytoSorb was used in conjunction with citrate dialysis (Multifiltrate; Fresenius Medical Care) in CVVHD mode
- Blood flow rate: 100 ml/min
- Anticoagulation: citrate
- CytoSorb adsorber position: pre-hemofilter

Measurements
- Demand for catecholamines
- Inflammatory parameters (IL-6, PCT)
- Renal function (excretion)

Results
- 1. treatment: Reduction of IL-6 from 4800 pg/ml to 315 pg/ml and hemodynamic stabilization of the patient with significantly decreased needs for catecholamines
- 2. treatment: reduction of IL-6 from 315 pg/ml to 79 pg/ml and further stabilization of the patient
- Additional decrease of inflammatory parameters (CRP) and of PCT from initially 21 ng/ml to 11.9 ng/ml during the course of both treatments
Patient Follow-Up

- After the described initial clinical improvement the patient developed recurring septic episodes in the further course with necessity for another operation due to persisting pancreatic fistula and a complete necrosis of the remaining pancreas with futile prognosis, and as a result the patient died.

CONCLUSIONS

- Combined treatment of CRRT with CytoSorb resulted in a clear and quick stabilization of hemodynamics with declining needs for catecholamines and a pronounced reduction of inflammatory mediators.
- Handling of the adsorber was easy and safe.
CytoSorb in pneumogenic septic shock after ethyltoxic bone marrow depression and increased comorbidity (alcohol abuse, 3-fold ACVB)

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This case study reports on a 53-year-old male patient (medical history of 3-fold ACVB and pacemaker implantation) who presented at the hospital with ethyltoxic pancytopenia, acute alcohol withdrawal delirium and hypostatic bilateral pneumonia.

Case presentation

- Immediate transfer to intensive care unit – at this point of time the patient was awake, responsive, tachycardic and hallucinating
- Instant initiation of anti-delirious therapy (gamma hydroxybutyrate, Haloperidol) as well as administration of ampicillin/sulbactam for treatment of community acquired pneumonia
- On the 2nd day, deterioration of the patients' clinical condition, delirious alcohol withdrawal went more complex and the patient exhibited psychological abnormalities – changeover of sedation to midazolam
- Respiratory exhaustion in the afternoon followed by intubation and mechanical ventilation
- Diagnosis of complete lower lobe pneumonia left and diffuse pneumonia right
- Change of antibiotic regimen to meropenem
- Aggravation of the patients' condition to septic shock (circulation, kidney, lung)
- Drastically increased inflammatory parameters (PCT 44 ng/ml, CRP 176 mg/dl, lactate 8.8 mmol/l)
- Further deterioration of renal function with oliguria (excretion 20 ml/h), however tending towards further declining urinary output
- Excessive increase of catecholamine dosages (norepinephrine 1 µg/kg/h)
- Due to acute renal as well as lung failure, a sharp increase of inflammatory markers and progressive need for catecholamine and septic shock with multiple organ failure CytoSorb was started simultaneously with early CRRT

Treatment

- One CytoSorb treatment session for 72 hours (CRRT and CytoSorb were started and stopped simultaneously after one cycle of CVVH a 72 hours)
- CytoSorb was used in conjunction with citrate dialysis (Prismaflex; Gambro) in CVVHDF mode
- Blood flow rate: 150 ml/min
- Anticoagulation: citrate
- CytoSorb adsorber position: post-hemofilter

Measurements

- Demand for catecholamines
- Inflammatory parameters (PCT, CRP, leucocytes)
- Renal function (excretion)
- Lactate

Results

- Clear stabilization of hemodynamics during the course of the combined CVVH and CytoSorb treatment with a reduction of catecholamine dosages – after 6 hours, norepinephrine could be reduced significantly and after 72 hours dosages were at 0.08 µg/kg/h constantly
- Improvement of lung function after 72 hours of treatment, also invasiveness of mechanical ventilation could be reduced significantly (FiO2 from 70% to 45 %)
- Marked decrease of inflammatory parameters during the course of the treatment: PCT to 26 ng/ml, CRP to 129 mg/dl
- Normalization of leucocytes to almost normal values of 11.200/µl
- Lactate stable at 1.4 mmol/l
- Quick recovery of kidney function after one cycle of CVVH and CytoSorb (72 hours) all the way to polyuria (150-200 ml/h)
**Patient Follow-Up**
- Termination of renal replacement therapy after 72 hours together with CytoSorb
- In the further course a second septic episode developed (MRSA, 40°C fever) with increasing dosages of catecholamines, which was handled successfully within 6 hours (however without application of CytoSorb)
- Patient clearly stabilized, still intubated and ventilated, sedation with Propofol and Sufentanil

**CONCLUSIONS**
- Acute phase of septic shock could be overcome surprisingly quick despite multiple comorbidities (bone marrow depression, alcohol abuse, vitamin deficiency, heart disease, severely impaired synthesis function of the liver)
- Physicians did not expect the patient to survive the next day
- Kidney function was unexpectedly re-established after 48 hours of CVVH+CytoSorb, which to the impression of the treating physicians is quite uncommon to happen in septic shock (potentially due to the reduction of plasma cytokine levels)
- Clear stabilization and consolidation of hemodynamics and inflammatory mediators during CytoSorb treatment
- Handling of the adsorber was easy and safe, even after 72 hours there were no issues with transmembrane pressure and clotting
CytoSorb in Staph aureus sepsis and myositis-associated rhabdomyolysis

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This case study reports on a 61-year-old female patient who presented at the hospital with fever, vomitus and signs of sepsis a few days after completion of her 11th cycle of adjuvant chemotherapy with Paclitaxel due to mamma carcinoma.

Case presentation
- Rapid deterioration of her hemodynamic situation and kidney function
- High plasma levels of inflammatory markers – leucocytes 24,000/µl, CRP 380 mg/l, PCT 45.1 ng/ml
- Additional clinically pronounced myositis (muscle inflammation) with myoglobin plasma levels of 6049 µg/l
- Erythema multiforme with proof of Staph aureus in wounds and suspicion of toxic shock syndrome
- Development of acute anuric renal failure with immediate initiation of citrate dialysis (CVVHD)
- Progressive deterioration of hemodynamic condition with high need for catecholamines (norepinephrine 4 mg/h)
- In the further course fulminant septic shock with renal and circulatory failure as well as highly elevated markers of inflammation resulting in the installation of CytoSorb into the CRRT circuit

Treatment
- One CytoSorb treatment session for 24 hours
- CytoSorb was used in conjunction with citrate dialysis (Multifiltrate; Fresenius Medical Care) in CVVHD mode
- Additionally, an EMic2 filter was installed for the treatment of highly elevated myoglobin plasma concentrations (CytoSorb in series before EMic2 filter)
- Blood flow rate: 150 ml/min
- Anticoagulation: citrate
- CytoSorb adsorber position: pre-hemofilter

Measurements
- Demand for catecholamines
- Inflammatory parameters (IL-6, PCT, CRP, leucocytes)
- Renal function (excretion)
- Lactate

Results
- Hemodynamic stabilization with reduction of catecholamine dosages to 2 mg after termination of CytoSorb treatment and gradual weaning from catecholamines with complete stop 4 days after start of CytoSorb therapy
- Leucocytes fell to 18000/µl four hours after start of CytoSorb treatment and continued to decrease to normal values in the further course
- CRP plasma levels decreased to 260 mg/l four hours after start of CytoSorb treatment and to 85 mg/l in the further course
- PCT could be reduced to 13.7 mg/l after 24 hours of CytoSorb treatment
- Myoglobin plasma concentrations were reduced to 3168 µg/l and to 665 mg/l in the further course
Patient Follow-Up

- Further improvement of all organ functions in the following days
- Following intermittent termination attempts CRRT could be stopped 16 days after start of CytoSorb therapy
- Patient could be discharged to rehabilitation with persistent critical illness myopathy and neuropathy 32 days after CytoSorb treatment

CONCLUSIONS

- Combined treatment of CRRT with CytoSorb resulted in a clear and quick stabilization of hemodynamics with declining needs for catecholamines and a significant reduction of inflammatory mediators
- The combined application of CytoSorb and the EMIC2 filter was also associated with a rapid reduction of myoglobin plasma levels as a result of myositis-associated rhabdomyolysis
- For the treating physicians, this was the 2nd case with an excellent experience using CytoSorb in a patient with fulminant septic shock
- Handling of the adsorber was easy and safe
CytoSorb in septic shock with multiple organ failure and ARDS (fast-in/fast-out)

Dr. Martin Bergold, Senior Consultant Clinic for Anaesthesiology, Intensive Care Medicine and Pain Management, Evangelisches Krankenhaus Oldenburg, Germany

This case study reports on a 64-year-old male patient (medical history of arterial hypertension and insulin-dependent diabetes mellitus) who all of a sudden deteriorated massively (hemodynamically and respiratory) during his 3-week hitherto uneventful neurological first stage rehabilitation after media and cerebellar infarction.

Case presentation
- Diagnosis of sepsis with immediate start of antibiotic therapy (piperacillin/tazobactam)
- Despite antibiotic therapy further aggravation of his clinical condition all the way to septic shock with further change of antibiotic regimen to Meropenem and Teicoplanin
- Unstable hemodynamics despite 0.35 µg/kg/min norepinephrine: cardiac index 2.3 l/min/m², SVRI 1100 dyn*s*cm-5*m², ELWI 16 ml/kg, lactate 6.7 mmol/l
- Sharp increase of inflammatory parameters PCT 1.28 ng/ml, IL-6 7315 pg/ml, leucocytes 70.000/µl, CRP 4.9 mg/dl
- Development of ARDS with proof of pseudomonas spec and diagnosis of pseudomonas-pneumonia
- Despite initial spontaneous diuresis and normal retention parameters renal function deteriorated rapidly
- Due to acute anuric renal failure, sharp increase of inflammatory markers and progressive need for catecholamine and septic shock with multiple organ failure CytoSorb was started simultaneously with CRRT

Treatment
- Three CytoSorb treatment sessions for 24 hours each
- CytoSorb was used in conjunction with citrate dialysis (Multifiltrate; Fresenius Medical Care) in CVVHD mode
- Blood flow rate: 100 ml/min
- Anticoagulation: citrate
- CytoSorb adsorber position: pre-hemofilter

Measurements
- Demand for catecholamines
- Inflammatory parameters (IL-6, PCT, CRP, leucocytes)
- Renal function (excretion)
- Lactate

Results
- Clear stabilization of hemodynamics during the course of the three CytoSorb treatments under 0.25 µg/kg/min norepinephrine and vasopressin: cardiac index now 3.54 l/min/m², SVRI 1600 dyn*s*cm-5*m², ELWI 8 ml/kg, in TEE LV-EF 30-40%
- Decrease of inflammatory parameters during the course of the three CytoSorb treatments: IL-6 to 1871 pg/ml, PCT to 0.44 ng/ml, CRP to 7.9 mg/dl, leucocytes to 8700/µl
- Lactate level stable at 2.2 mmol/l

Patient Follow-Up
- Cessation of renal replacement therapy 6 days after the last CytoSorb treatment
- Complete recovery after acute septic phase with exception for his neurologic underlying problem (rehabilitation due to media and cerebellar infarction)
- Transfer to neurological first stage rehabilitation
Patient Follow-Up

- Cessation of renal replacement therapy 6 days after the last CytoSorb treatment
- Complete recovery after acute septic phase with exception for his neurologic underlying problem (rehabilitation due to media and cerebellar infarction)
- Transfer to neurological first stage rehabilitation

CONCLUSIONS

- Clear stabilization and consolidation of hemodynamics and inflammatory mediators under CytoSorb within 48 hours
- Control of septic shocks within a short period of time
- Handling of the adsorber was easy and safe
CytoSorb in pneumogenic sepsis due to influenza A H1N1

Dr. Markus Nitsch & Dr. Hendrik Liedtke, Clinic for Anaesthesiology, Intensive Care, Palliative, Emergency Medicine and Pain Therapy, Hospital St. Elisabeth and St. Barbara Halle (Saale) GmbH, Germany

This case study reports on a 68-year-old male patient (medical history of COPD IV°, atrial fibrillation hypertension and chronic nicotine and alcohol abuse) who was admitted to the hospital by emergency medical service.

Case presentation
- Direct transfer from emergency department to ICU under non-invasive ventilation
- Intubation and invasive ventilation due to persistent hypercapnia (respiratory acidosis)
- CT diagnosis did not show acute infiltration, at bronchoscopy no secretion in bronchi visible, bronchial wall thickening due to COPD was the only abnormality
- In the further course significantly increasing needs for volume and norepinephrine (2.3 µg/kg/min)
- Suspicion for pneumogenic sepsis with immediate start of antibiotic therapy (piperacillin/tazobactam)
- Progressing renal failure with oliguria up to anuria
- Increase of pCO2 to 18 kPa, pO2 15 kPa at FiO2 of 0.5, pH 7.04
- Increased inflammatory parameters: PCT 1.28 ng/ml, CRP 114.4 mg/l
- Microbiological finding: Influenza A H1N1 (from bronchoscopy at admission)
- Due to pneumogenic sepsis and increasing needs for catecholamines and volume, CytoSorb was started simultaneously with CRRT

Treatment
- Two CytoSorb treatment sessions for 24 hours each (pause interval of 3 hours between both treatment sessions)
- CytoSorb was used in conjunction with citrate dialysis (Multifiltrate; Fresenius Medical Care) in CVVHD mode
- Anticoagulation: citrate
- CytoSorb adsorber position: pre-hemofilter

Measurements
- Demand for catecholamines
- Demand for volume
- Inflammatory parameters (PCT, CRP)

Results
- Norepinephrine could be reduced as early as 6 hours after start of CytoSorb - first to 1.8 µg/kg/min and to 0.6 µg/kg/min over the next 24 hours
- After stop of the first CytoSorb treatment the norepinephrine dosage had to be increased again to 2 µg/kg/min
- After start of the second CytoSorb treatment, noradrenaline could be tapered off within the next 12 hours
- Volume requirement declined significantly over this time
- PCT and CRP plasma levels initially increased but continued to fall in the further course following the second treatment session
Patient Follow-Up
- Cessation of renal replacement therapy 2 days after the last CytoSorb treatment with full recovery of spontaneous diuresis after stimulation with diuretics
- Weaning trials over 6 weeks after the end of CytoSorb, thereafter adjustment to non-invasive ventilation
- Transfer to pneumology department with persistent critical illness myopathy and neuropathy
- Discharge from hospital 10 weeks after initial admission into early stage rehabilitation

CONCLUSIONS
- Remarkable stabilization of hemodynamics with declining catecholamine and volume requirements under CytoSorb within 48 hours
- According to medical team they were positively surprised because of the rapid stabilization of the patient and due to the fact that catecholamines could be tapered off that rapidly
- Handling of the adsorber was easy and safe
Case report of a patient with multiorgan failure due to severe SIRS in cardiac failure additionally treated with CytoSorbents haemadsorption as an adjunctive therapy

Klaus Kogelmann, Matthias Drüner, Dominik Jarczak, Department of Anaesthesiology and Intensive Care Medicine, Hospital Emden

This case study reports on a female patient who was admitted to hospital after she collapsed several times at home.

Case presentation
- Patients' medical history included peripheral arterial obstructive disease, arterial hypertension and a previous minor stroke.
- Glasgow Coma scale was 11, heart rate 20 bpm, hypothermia 30 °C, metabolic acidosis with pH 7.2, no measurable blood pressure.
- After immediate resuscitation the patient developed severe SIRS and multiple organ failure with cardiogenic shock due to refractory cardiac arrhythmia.
- Initial ultrasound of heart function showed diffuse hypokinesia and an ejection fraction (EF) of around 45 %, with a heart rate of 36 bpm.
- 24 hours of conventional treatment (differentiated catecholamine therapy with combined norepinephrine and adrenaline, ultrasound guided volume therapy, lung-protective ventilation, temporary cardiac pacemaker).
- Following this, ultrasound showed diffuse dysfunction and hypokinesia with an EF of 50 %.
- Laboratory tests and electrocardiography on admission showed neither myocardial infarction nor evidence of infection but highly elevated liver enzymes and creatinine.
- Due to high and stable catecholamine support associated with persistent renal failure, CytoSorb therapy and CRRT were initiated.

Treatment
- Duration of therapy with CytoSorb was 72 hours.
- Three CytoSorb treatment sessions for 24 hours each.
- CytoSorb was used in conjunction with citrate dialysis (Multifiltrate; Fresenius Medical Care) in CVVHD mode.
- Blood flow rate: 100 ml/min.
- Anticoagulation: citrate.
- CytoSorb adsorber position: pre-hemofilter.

Messungen
- Before, during and after treatment:
  - SAPS II-Score, SOFA-Score
  - Mean Arterial Pressure
  - Requirement for norepinephrine
  - Blood lactate level
- During therapy:
  - Demand of norepinephrine (µg/h vs. mmHg MAP).
Results
- During CytoSorb therapy the authors observed a decrease in catecholamine demand of more than 95%, and 72 h after therapy the patient was free of catecholamines.
- SOFA Score did not change; SAPS II-Score decreased to 50% of its initial value.
- Blood lactate decreased from 46.9 to 21.4 mg/dl.
- Liver function tests improved; AST decreased from 5355 U/L to 431 U/L 3 days later; ALT decreased from 4858 U/L to 888 U/L and LDH decreased from 6859 to 242 U/L.

Patienten Follow-Up
- 12 days after treatment the liver enzymes had returned to normal values.
- Chest X-ray 10 days after admission showed only slight effusions, 6 days later she could be weaned from ventilation, the patient was alert, vigilant and stable clinically without the requirement for catecholamines.
- During therapy, blood natriuretic peptide level showed a tenfold increase to 1.959 pg/ml as a marker of left ventricular dysfunction.
- Coronary angiography showed three vessel coronary artery disease with ischemic cardiomyopathy as the reason for the patient's cardiac arrhythmia which had led to pump failure and the severe SIRS.

CONCLUSIONS
- Treatment using CytoSorb adsorption in this patient with severe cardiac failure due to ischemic cardiomyopathy was associated with significant clinical improvement, was safe and without apparent side effects.
- The authors note that CytoSorb therapy was helpful even in a patient with marked cardiac failure leading to severe SIRS.
CytoSorb in pneumogenic septic shock after mitral valve reconstruction

Dr. Bastian Huschens, Dr. Ender Demircioglu, Department of Thoracic and Cardiovascular Surgery, University Hospital Essen

This case study reports on a 45-year-old female patient with mitral valve regurgitation III° and tricuspid valve regurgitation I-II° who underwent elective mitral valve reconstruction and then gradually deteriorated during her postoperative intensive care course.

Case presentation

- On the 3rd postoperative day (POD) development of a ventilator-associated pneumonia culminating in pneumogenic sepsis with accompanying ARDS
- Increased plasma levels of inflammatory parameters: PCT 29.4 ng/ml, CRP 21.2 mg/dl, elevated lactate 6.1 mmol/l
- Antibiotic regimen: ciprofloxacin, tazobactam/piperacillin
- Septic shock with multiple organ failure: hemodynamics (norepinephrine dose on the 2nd POD 1.5 µg/kg/min), lung, kidney, liver
- Development of sepsis-associated liver dysfunction (bilirubin 3.9 mg/dl on the 1st POD and further increasing levels with a peak value on the 6th POD of 20 mg/dl)
- Further deterioration of renal function, initially oliguric but trending towards decreasing excretion culminating in anuria and initiation of continuous renal replacement therapy (CVVH) on POD 5
- Pre-ECMO therapy: kinetic positioning for 4 days
- Initial stabilization of the circulatory situation (epinephrine dose on the 7th POD 0.05 µg/kg/min)
- Second septic insult along with hemodynamic deterioration on POD 8 with 0.2 µg/kg/min and worsening liver failure (plasma bilirubin levels with peak value of 38.5 mg/dl, quick 24%, hepatic encephalopathy), lactate at 3.1 mmol/l
- Escalation of antibiotic therapy from ciprofloxacin, tazobactam/piperacillin to imipenem/cilastatin
- Due to acute renal- and respiratory failure, sharp increase in inflammatory markers and progressive need for vasopressors as well as further increase in bilirubin levels indicative of progressive liver failure, CytoSorb was installed into the CVVH circuit on the 8th POD

Treatment

- 8 CytoSorb treatment sessions for 24 hours each and a total treatment period of 8 days
- CytoSorb was used in conjunction with citrate dialysis (Multifiltrate; Fresenius Medical Care) in CVVHDF mode
- Blood flow rate: 100 ml/min
- Anticoagulation: initially heparin, after recovery of liver function change to citrate
- CytoSorb adsorber position: pre-hemofilter
Measurements

- Demand for catecholamines
- Inflammatory parameters (PCT, CRP)
- Renal function (excretion)
- Lactate
- Bilirubin
- Ammonia

Results

- After implementation of CytoSorb there was an initial deterioration of the hemodynamic situation with increasing needs for catecholamines from 0.2 to 0.6 µg/kg/min for the first 24 hours, however there was a significant stabilization of hemodynamics in the further course of combined CVVH-CytoSorb treatment with a clear reduction in norepinephrine requirements. After 48 hours norepinephrine could be significantly reduced and was completely tapered off on the 12th POD
- Reduction of inflammatory parameters during the course of treatments: PCT from 43.5 ng/ml on the first treatment day to 7.42 ng/ml on the 2nd and 1.35 ng/ml on the last treatment day; CRP from 31.8 mg/dl on the first treatment day to 21.3 mg/dl on the 2nd and 14.7 mg/dl on the last treatment day
- Lactate from 1.3 mmol/l on the first treatment day to 4.6 mmol/l on the 2nd and 2.0 mmol/l on the last treatment day
- Bilirubin from 25.6 mg/dl on the first treatment day to 17.2 mg/dl on the 2nd and 4.7 mg/dl on the last treatment day
- Ammonia from 64 µg/dl on the first treatment day to 55 µg/dl on the 2nd, 135 µg/dl on the 4th, 201 µg/dl on the 5th and 6th treatment day and 47 µg/dl after the last treatment
- No recovery of renal function

Patient Follow-Up

- Patient still dialysis-dependent on POD 24
- Regressive hepatic encephalopathy along with significant neurological improvement (vigilance)
- Patient is free of catecholamines, complete regeneration of liver function including stabilization of coagulation disorder even without substitution
- CPAP without pressure support, alternated with nightly BiPAP training
- Transfer of the patient to a weaning clinic while awake, oriented and hemodynamically stable

Conclusions

- The most obvious effect was the significant and rapid stabilization of liver function and neurological improvement
- Acute phase of septic shock could be overcome surprisingly quickly
- Clear stabilization and consolidation of hemodynamics and inflammatory mediators with CytoSorb
- Handling of the adsorber was easy and safe
CytoSorb in septic shock after perforated Ulcus ventriculi

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This case study reports on a 43-year-old male patient, who was transferred to hospital via emergency boat and ambulance service from Langeoog island with initially belt-shaped and then diffuse radiating acute pain in the upper abdomen, dark vomitus, diarrhea and dyspnea.

Case presentation

- Diagnosis: perforated ulcus ventriculi at the small curvature
- Immediate emergency laparoscopy and laparotomy within 2 hours after admission followed by surgical suturing and covering of the perforation
- The patient was transferred to ICU intubated and ventilated
- At this time the patient was hemodynamically unstable, hypotonic, tachycardic with high requirement for catecholamines (noradrenaline 0.5 ug / kg / min)
- Significantly increased inflammatory parameters: PCT> 200 ng/ml, leukocytes 6.900/µL, CRP >27 mg/dl
- Advanced hemodynamic monitoring showed septic shock with high volume requirements (SVRI 1500 dyn*s*cm⁻²*m⁻², ELWI 5.6 ml/kg, GEDI 496 ml/m²)
- High loading volumes (positive fluid balance 12 liters) with poor and further decreasing spontaneous diuresis (200 ml/day), creatinine 5.8 mg/dl, GFR 11.3 ml/min, urea 95 mg/dl
- Initiation of antibiotic therapy with ertapenem followed by additional calculated antifungal treatment with caspofungin
- Hydrocortisone 200 mg/day, continuous Amiodarone with 300 mg loading dose (maintenance dose 900 mg/d)
- Insertion of a Shaldon catheter and initiation of continuous veno-venous hemodialfiltration (CVVHDF)
- Due to acute renal failure, sharp increase in inflammatory markers, progressive need for vasopressors and septic shock, CytoSorb was started 24 hours after initiation of CVVHDF

Treatment

- Two consecutive CytoSorb treatment sessions for 24 hours each
- CytoSorb was used in conjunction with citrate dialysis (Prismaflex; Gambro) in CVVHDF mode
- Blood flow rate: 150 ml/min
- Anticoagulation: citrate
- CytoSorb adsorber position: post-hemofilter

Measurements

- Demand for catecholamines
- Advanced hemodynamic monitoring parameters (SVRI, GEDI)
- Lactate clearance
- Inflammatory parameters (PCT, CRP)
- Renal function (excretion)
Results

- Clear stabilization of hemodynamics during the course of the two CytoSorb treatments (GEDI 840 ml/m², SVRI 2600 dyn*s*cm⁻⁵*m²⁻²)
- With installation of the adsorber the norepinephrine dose could be reduced significantly to around 1/5 of the initial dose after completion of the first CytoSorb treatment and a further reduction to 0.08µg/kg/min after completion of the second treatment. Five days after the first treatment norepinephrine could be completely tapered off
- Reduction of inflammatory parameters during the two treatments: PCT to 45 ng/ml after the first and to 23 ng/ml after the second treatment, CRP at >27 mg/dl after the first treatment and 7.4 mg/dl after the second treatment
- Two days after completion of CytoSorb therapy increasing spontaneous diuresis
- Antibiotic dosages did not have to be adjusted at any time

Patient Follow-Up

- Cessation of renal replacement therapy 5 days after last CytoSorb treatment
- Extubation on postoperative day 11
- Antibiotic treatment with ertapenem could be discontinued 10 days and the antifungal treatment 14 days after admission
- After extubation, patient had ongoing delirium which normalized over the next 4 days
- No neuropathic sequelae
- Transfer to IMC 16 days after initial admission and 4 days later to the normal ward

Conclusions

- Clear stabilization and consolidation of hemodynamic and inflammatory mediators with CytoSorb within 48 hours
- Conventional therapy using the sepsis bundle was not enough to hemodynamically stabilize the patient during his acute septic phase, however, after using the CytoSorb adsorber this could be achieved in a short period of time
- The application of CytoSorb therapy was simple, safe with no problems installing the adsorber in a post-hemofilter position
First description of single-pass albumin dialysis combined with cytokine adsorption in liver failure and hemophagocytic syndrome resulting from generalized herpes simplex virus 1 infection

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This case study reports on a 50-year-old immunocompetent woman who was admitted to hospital for acute hepatitis with acute liver failure.

Case presentation
- Liver biopsy revealed acute liver cell necrosis due to herpes simplex virus type 1 (HSV-1)
- Despite antiviral therapy liver failure progressed and patient was transferred to ICU
- Rapid development of MOF with hepatic coma, severe coagulopathy, acute anuric renal failure, respiratory insufficiency and arterial hypotension
- Patient was listed for highly urgent liver transplantation
- Additional diagnosis of hemophagocytic lymphohistiocytosis (HLH), secondary to HSV-1-infection
- Hemodialysis and extracorporeal liver support were initiated using MARS ®-therapy (6 hours 1st day, 19 hours 2nd day)
- Increasing need for NE and excessively elevated concentrations of inflammatory markers indicated ongoing severe SIRS
- Hence extracorporeal therapy was changed to CVVHD with SPAD (12 hours of treatment)

Treatment
- One session of CytoSorb treatment was performed with a treatment duration of 20 hours
- CytoSorb was integrated in a predialyzer position
- Regional anticoagulation was performed using sodium citrate

Measurements
- Need for vasopressors
- IL-6, bilirubin

Results
- IL-6 levels fell from 81059 pg/ml to 17177 pg/ml after 12 hours of treatment
- Noradrenaline dosage was reduced to 0.25 µg/kg/min
- No further clinical deterioration of the patient
- Antiinfective therapy was conducted with Acyclovir, with no reported adaption of dosage during CytoSorb treatment
- Reduction of the moderately elevated bilirubin with SPAD + CytoSorb

Patient Follow-Up
- Successful OLT on 4th day on ICU
- Further improvement after OLT

Conclusions
- First report of the combined use of CytoSorb with SPAD in a patient suffering from ALF and probable HLH with severe SIRS listed for liver transplantation
- Major results of the intervention were a marked decrease of IL-6, and bilirubin, as well as a reduction of vasopressor need
- Treatment was safe and well-tolerated, without any adverse events
- Existing liver support technique (MARS ® treatment) had no effect on the reduction of bilirubin
- CytoSorb might be a useful tool for patients with acute liver failure and severe hyperinflammatory syndromes
CytoSorb in septic shock and multi organ failure after burn injury

Dr. Markus Engel
Senior Consultant Medical ICU, Hospital Bogenhausen

This case study reports on a 27-year-old patient who was admitted to emergency department in status post burn injury (25% TBSA)

Case presentation
- Burn injury of face, arms, hands and lower legs on both sides after flash fire during work as craftsman. Primary care by emergency physician on site including intubation and analgosedation and subsequent transport to hospital by helicopter
- On admission intubated and ventilated and with stable circulation requiring low dose catecholamine administration. Primary wound care and vaculeal dressing of both hands
- On day 3 uneventful extubation with stable pulmonary and circulatory functions not requiring catecholamine administration
- Here after debridement and closure of arm and leg wounds with Suprathel
- In the following, however worsening of the cardiopulmonary and renal functions and after the pressure supported NIV approach had failed the indication for intubation was given. In the course of that further deterioration of circulatory instability requiring high dose administration of norepinephrine. Decreasing diuresis despite high doses of furosemide.
- Chest x-ray diagnosis showed progressive pulmonary alterations in terms of ARDS. Echocardiography showed only low grade reduced left ventricular function and no real cardiac dysfunction.
- Due to multiple organ failure because of the massive inflammatory reaction as well as the persisting high doses of catecholamines needed (norepinephrine up to 5mg/h) treatment with CytoSorb was started after renal failure had also required CRRT.

Treatment
- One CytoSorb treatment sessions for a total period of 24 hours
- CytoSorb was used in conjunction with CRRT (multiFiltrate, Fresenius Medical Care) in CVVHD mode
- Anticoagulation: citrate
- CytoSorb adsorber position: pre-hemofilter

Measurements
- Demand for catecholamines
- Lactate
- IL – 6 levels

Results
- Quick hemodynamic stabilization of the patient with significantly decreased needs for catecholamines initially and complete tapering of catecholamines after 48 hrs.
- Effective reduction of lactate and IL-6 levels during the CytoSorb sessions

Patient Follow-Up
- Proof of 3MRGN Pseudomonas as well as diagnosis of HIT
- In the further course end of CRRT and extubation of (tracheotomized) patient
- Finally discharge with stable overall situation and plain wound conditions
Conclusions

- Treatment with CytoSorb resulted in a significant and quick stabilization of hemodynamics as well as an effective reduction of lactate and IL-6 plasma levels
- Treatment was easy to apply and safe
First report of cytokine removal using CytoSorb in severe noninfectious inflammatory syndrome after liver transplantation

Tomescu DR, Dima SO, Ungureanu D, Popescu M, Tulbure D, Popescu I

In this report the authors present the case of a 46-year-old man with primary graft nonfunction after liver transplantation who underwent emergency retransplantation with an ABO-incompatible graft.

Case presentation

- 46-year-old man who underwent deceased donor liver transplantation (LT) for Hepatitis-B-Virus (HBV) and alcoholic cirrhosis
- Postoperatively, the patient remained neurologically unresponsive, could not be extubated, and there was a massive increase in serum transaminases and bilirubin
- Hyperdynamic hemodynamic status with a high cardiac index (CI) and low systemic vascular resistance index (SVRI) requiring vasopressor support was noted immediately after surgery
- Laboratory results showed disseminated intravascular coagulopathy and one session of plasma exchange was performed for severe coagulopathy and cholestasis
- Acute graft dysfunction was diagnosed on the 1st postoperative day with emergency retransplantation (ABO incompatible) 36 hours after the first LT

Treatment

- CytoSorb was used in conjunction with CVVH during retransplantation for the entire duration of surgery (total treatment time of 7 hours) and on the first postoperative day with a treatment time of 12 hours
- CytoSorb was installed into the CVVH circuit (multiFiltrate® using an Ultraflux® AV 600S hemofilter, Fresenius Medical Care)
- Blood flow rates were 150 ml/min
- Anticoagulation was achieved using heparin
- Intraoperative immunosuppression consisted of 500 mg methylprednisolone and 20 mg basiliximab

Measurements

- Cytokine levels were measured at the beginning of surgery (T1), after graft reperfusion (T2), at the end of surgery (T3) and before (T4) and after (T5) the second CytoSorb treatment
- Hemodynamic parameters, biochemical assays and vasopressor support were noted

Results

- During the first treatment pro-inflammatory cytokines IL-1b, TNF-a, IL-6 and IL-8 levels decreased, anti-inflammatory cytokines IL-4, IL-13 were constant within the normal range, IL-10 and MCP-1 levels decreased 10-fold to about normal levels
- Improvement in hemodynamics with a stabilized MAP and a continuous decrease in vasopressor support (NE) during surgery (NE discontinued at the end of surgery)
- The use of CytoSorb during the second session was associated with an improvement in cardiac output and SVRI
- Lactate levels and central venous oxygen saturation (ScvO2) returned to normal values
- A decrease in platelet count was observed during both treatments (attributed to a multifactorial etiology: CVVH procedure, use of heparin, intraoperative blood loss, and possibly to the use of CytoSorb)
- The treatment was well tolerated with no obvious adverse effects
Patient Follow-Up

- Patient was extubated 12 hours after re-transplantation
- Liver function returned to normal within the next 5 days
- Discharge from the Post Anaesthesia Care Unit 7 days after retransplantation
- Discharge from hospital on the 35th postoperative day
- At the 4 months follow-up the patient was in good clinical state with normal liver function
- A normal liver function was also recorded at the 1-year follow-up

Conclusions

- First use of CytoSorb during CVVH in a patient undergoing re-transplantation with AB0 incompatible graft for Acute Graft Dysfunction
- The use of CytoSorb was associated with an excellent outcome in terms of improved hemodynamic parameters, rebalancing pro-inflammatory and anti-inflammatory cytokines and patient survival
- Hemoadsorption with CytoSorb may represent an approach to bridge patients with acute liver failure or Acute Graft Dysfunction to liver transplantation
Improvement of hemodynamic and inflammatory parameters by combined hemoadsorption and hemodiafiltration in septic shock

Steffen R. Mitzner, Martin Gloger, Jörg Henschel, Sebastian Koball, Divisions of Nephrology and Pulmonology and Internal Intensive Care, Department of Internal Medicine, University of Rostock, Germany

This case study reports on a 80-year-old male patient stable on chronic hemodialysis for more than 12 months who was admitted to emergency department after he collapsed at the end of a regular dialysis session.

Case presentation

- Past history included coronary artery disease with a myocardial infarction 14 months ago, end-stage renal disease due to nephrosclerosis, arterial hypertension and diabetes mellitus type II
- On examination, patient had fever (39.2°C), moist rales in bilateral lungs, \( \text{O}_2 \)-saturation 79%, BP 126/60 mmHg, HR 130 beats/min, lactic acidosis with pH 7.1, APACHE II 33, SAPS II 48
- Later blood cultures remained negative, however, bronchoalveolar lavage was positive for Staph aureus
- Upon further deterioration of the circulatory situation, patient was diagnosed of having pneumogenic septic shock
- Intubation for mechanical ventilation and admission to ICU
- Immediate start on Ceftriaxone and Clarithromycin and 0.2 µg/kg/min noradrenaline
- On day 3 of the ICU stay the patient was in clinical need for renal replacement therapy
- Interleukin (IL) 6 level was elevated to 665 pg/m
- Due to clinical need for renal replacement therapy, a sharp increase of inflammatory markers, high need for catecholamines and septic shock with multiple organ failure CytoSorb was additionally installed into the CRRT circuit

Treatment

- One CytoSorb treatment session for 24 hours
- CytoSorb was used in conjunction with citrate dialysis (Multifiltrate; Fresenius Medical Care) in CVVHD mode
- Anticoagulation: citrate
- CytoSorb adsorber position: pre-hemofilter

Measurements

- Demand for catecholamines
- Inflammatory parameters (IL-6, PCT, CRP, leucocytes)
- Renal function (creatinine)
Results

- Noradrenaline could be reduced from a maximum of 3.0 to 0.4 µg/kg/min while MAP remained stable
- Values of IL-6, CRP, creatinine, procalcitonin, and leukocytes decreased during treatment
- Antibiotic therapy was performed without necessity to adjust doses at any time during CytoSorb treatment

Patienten Follow-Up

- Values of inflammatory markers continued to decrease in the following days

CONCLUSIONS

- Clear stabilization and consolidation of hemodynamics and inflammatory mediators under CytoSorb
- Treatment appeared to be safe and was well tolerated by the patient
This case study reports on a 55-year-old male patient (pre-existing conditions: obesity, insulin dependent type 2 diabetes mellitus, arterial hypertension), who was admitted to hospital with signs of sepsis due to an infection of his knee endoprosthesis implanted 1 year before, after an ambulatory puncture of the knee.

**Case presentation**

- On admission the patient exhibited high temperature and poorly detectable blood pressure, with an immediately identifiable infection focus (knee endoprosthesis)
- Immediate surgical removal of the knee endoprosthesis and insertion of a Palacos spacer
- Postoperative transfer to ICU. From this time the patient was already in septic anuric renal failure, including septic cardiomyopathy, lactic acidosis, and infection-related anemia (Hb 5.2 mmol/l, hematocrit 0.26, thrombocytes 127 Gpt/l, ATIII 46%)
- Greatly increased inflammatory (leukocytes 8.3 Gpt/l, PCT 42.5 µg/l, CRP 450.8 mg/l) and retention parameters (creatinine 633 mol/l, urea 27.3 mmol/l)
- Patient had ongoing circulatory instability (norepinephrine 1.1 µg/kg/min) with progressive clinical deterioration
- PICCO-guided volume therapy with Ringers-Acetate (12 l/24 h) with which norepinephrine doses could be decreased to 0.99 µg/kg/min
- Antibiotic treatment: Rifampicin/ciprofloxacin later changed to rifampicin/ceftriaxone
- Due to the high and ongoing demand for catecholamines with persisting renal failure, CytoSorb therapy was initiated in combination with CRRT

**Treatment**

- Three consecutive CytoSorb sessions for a total treatment time of 80 hours (two sessions for 24 hours each, one session for 32 hours)
- CytoSorb was used in conjunction with a Multifiltrate CRRT machine (Fresenius Medical Care) in CVVHD mode
- Blood flow rate: 180 ml/min
- Anticoagulation: citrate
- CytoSorb adsorber position: pre-hemofilter

**Measurements**

- Demand for catecholamines
- Inflammatory parameters (CRP, PCT, leucocytes)
- Renal function (creatinine, urea)
Results

- During the first treatment the hemodynamic condition of the patient could be stabilized considerably and the demand for catecholamines (noradrenaline) could be reduced from an initial dose of 0.99 µg/kg/min to 0.6 µg/kg/min, and in the course of the second treatment to 0.12 µg/kg/min and after the last treatment to 0.03 µg/kg/min.

- Rapid reduction of inflammatory parameters within the first five postoperative days (POD): PCT 10.76 µg/l (1. POD), 4.67 µg/l (2. POD), 4.1 µg/l (3. POD), 0.43 µg/l (5. POD); CRP 371.2 mg/l (1. POD), 148 mg/l (2. POD), 223 mg/l (3. POD), 94 mg/l (5. POD).

- Equally quick decrease of retention parameters under CVVHD within the first five postoperative days (POD): creatinine 387 µmol/l (1. POD), 148 µmol/l (2. POD), 117 µmol/l (3. POD), 98 µmol/l (5. POD); urea 21 mmol/l (1. POD), 10 mmol/l (2. POD), 9.5 mmol/l (3. POD), 8.0 µmol/l (5. POD).

Patienten Follow-Up

- Ongoing rapid and sustained stabilization of hemodynamics and organ functions.
- Extubation 1 day after the last CytoSorb treatment.
- Transfer to normal ward possible within a few days.

CONCLUSIONS

- Fast decision and the early start of treatment with CytoSorb in this patient led to a rapid stabilization of the clinical situation within the first 24 hours.
- According to the medical team, the patient would presumably not have survived without the CytoSorb treatment.
- Significant stabilization and consolidation of hemodynamic and inflammatory Parameters under CytoSorb.
- The application of CytoSorb therapy was easy and safe without any complications during or after the procedure.
CytoSorb in acute purulent abscess inflammation of the epididymis

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This case study reports on a 69-year-old male patient who fell on his right leg and hip, lying on the lower leg for about 4 hours with his entire weight, who was then salvaged by helpers and brought to the orthopedic department for further examination.

Case presentation

- Previously existing inflammatory problem of the epididymis for several days which was treated on an ambulatory basis
- X-ray examination showed no deterioration of any bone structures
- However, at this time the patient already exhibited elevated levels of creatinine (2.7 mg/dl), CRP (27 mg/dl) and leukocytes (32,000 /µl) as well as highly elevated liver function parameters
- The next day there was a further increase of CRP to 40 mg/dl, PCT to 17.3 ng/ml and CK to 24,000 U/l (CK-MB was only minimally increased)
- Primary suspicion for urosepsis followed by an immediate transfer to the urology department and subsequent operation with orchiectomy (septic testicles)
- Postoperative transfer to ICU and further increase of creatinine (to 8.2 mg/dl within 3 days), urea of 106 mg/dl, glomerular filtration rate of 7 ml/min, despite massive hydration
- Initiation of antibiotic therapy with ceftriaxone
- Immediately after admission to ICU and due to acute renal failure, a strong increase in plasma levels of inflammatory mediators and increasing needs for catecholamines, CytoSorb therapy was started

Treatment

- Six consecutive CytoSorb sessions for a total treatment time of 122 hours, the first two treatments were run for 12 hours, the additional 4 treatments for 24 hours each
- CytoSorb was used in conjunction with citrate dialysis (Prismaflex; Gambro) performed in CVVHD mode
- Blood flow rate initially 100 ml/min, then increase to 130 ml/min
- Anticoagulation: citrate
- CytoSorb adsorber position: post-hemofilter

Measurements

- Demand for catecholamines
- Inflammatory parameters (CRP, PCT)
- Renal function (creatinine, glomerular filtration rate)
- Creatine kinase (CK) and myoglobin
Results

- Within the following 4 days of CytoSorb treatment hemodynamics could be stabilized within just a few hours and catecholamines (norepinephrine) could be tapered out from an initial dose between 0.023-0.035 μg/kg/min in the following days
- In these 4 days CRP decreased from initially 40 mg/dl to 6.7 mg/dl, PCT could be reduced from 17.3 ng/dl to 0.64 ng/dl, leucocyte count decreased from 40,000/μl to 11,600/μl
- Myoglobin levels were reduced from 311 ng/ml to 104 ng/ml in the same time frame
- Likewise, CK- values were lowered from initially 24,000 U/l to 853 U/l and in the further course to 389 U/l

Patienten Follow-Up

- Eventual diagnosis of the pathologist: Acute purulent abscess inflammation of the epididymis spreading out to the testicles and the tissue of the spermatic cord
- 13 days after the last CytoSorb treatment the patient was transferred to the normal ward for further therapy in good general condition with further declining CRP (4.6 mg/dl), leukocytes and thrombocytes in the normal range, however still with increased renal retention parameters (creatinine 3.3 mg/dl)
- The clinical course of the beginning compartment syndrome of his right leg was also positive
- The right calf appeared much softer, no more pressure sensitivity, mobility intact
- Gross neurology was recurring and appropriately at the time of documentation, sensitivity present

CONCLUSIONS

- Significant stabilization and consolidation of hemodynamic and inflammatory parameters during and after CytoSorb therapy
- The application of CytoSorb therapy was easy and safe, with no application-specific complications emerging
Use of CytoSorb in severe refractory SIRS with multiple organ failure after post-resuscitation syndrome and cardiac surgery

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This case study reports on a 71-year-old male patient, who was admitted to hospital in an intubated, ventilated and highly catecholamine-dependent condition after experiencing an infarction-related avulsion of a papillary muscle and associated free mitral valve insufficiency and prior successful cardiopulmonary resuscitation.

Case presentation
- Mitral valve replacement emergency surgery with extended cardiopulmonary bypass time > 2 hours on the day of admission
- Post-operative transfer to ICU in intubated, ventilated, highly catecholamine-dependent condition and mechanical circulatory support with an intra-aortic balloon pump (IABP)
- On the first postoperative day, development of multiple organ failure with kidney (anuric, creatinine 2.2 mg / dl) and circulatory failure
- In addition, highly increased inflammatory parameters (IL-6 of 63 mg/l, CRP 167 mg/l, leukocytes 18,000/µl) and plasma myoglobin levels (2,001 µg/l)
- Initiation of renal replacement therapy (CVVHDF)
- Due to the high and stable catecholamine-dependency (norepinephrine 30 µg/min, adrenaline 4 µg/min), persistent renal failure, elevated inflammatory parameters, increased myoglobin plasma levels and condition after resuscitation and extended cardiopulmonary bypass time a CytoSorb adsorber was additionally installed into the CVVHDF circuit 12 hours after the start of renal replacement therapy

Treatment
- Three treatments with CytoSorb for a total treatment time of 72 hours (1st treatment for 12 hours, 2nd and 3rd treatment for 30 hours each)
- CytoSorb was used in conjunction with CRRT (Prismaflex, Gambro) performed in CVVHDF mode
- Blood flow rate: 100-140 ml/min
- Anticoagulation: citrate
- CytoSorb adsorber position: post-hemofilter

Measurements
- Demand for catecholamines
- Renal function (creatinine, excretion)
- Inflammatory parameters (IL-6, CRP, leucocytes)
Results

• Hemodynamic stabilization with significant reduction of catecholamines doses
• Kidney function – excretion rate rising after starting the 2nd treatment (400 ml/day), creatinine after 2nd treatment back in the normal range at 1.1 mg/dl
• On day 2 of treatment IL-6 fell to 21 ng/l – trend towards further decrease; leukocytes rose to 22,000/µL, however normalized to 13,000/µL two days after the last CytoSorb treatment
• Two days after completion of CytoSorb therapy CRP was at 120 mg/l - trend towards further decrease

Patienten Follow-Up

• Termination of renal replacement therapy and extubation 5 days after the last CytoSorb treatment
• Mobilization was possible still on intensive care unit
• 10 days after CytoSorb treatment the patient could be transferred to a normal ward
• Transfer without any residuals to a cardiac rehabilitation unit

CONCLUSIONS

• Treatment with CytoSorb was accompanied by an unexpectedly rapid and significant stabilization of hemodynamics and declining catecholamine dosages
• Based on the clinical course of this patient the internal decision was made that CytoSorb should be used in the future already intraoperatively in combination with the heart-lung machine when conditions apply as in the present case (emergency cardiosurgery, severe post- resuscitation syndrome SIRS) and should be continued in the post-operative course
• CytoSorb use should be further considered in septic patients not responding to conventional standard therapy within 12 hours
• Treatment with CytoSorb was safe and easy to apply
Use of CytoSorb to prevent acute renal failure during drug intoxication-associated rhabdomyolysis

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This case study reports on a 55-year-old female patient, found disoriented and poorly responsive at home who was subsequently brought to hospital by emergency ambulance.

Case presentation
- In the emergency room it was found that the patient had ingested 8 g of ibuprofen and 25 g of metamizol (~ 50 tablets) as well as potassium bromatum (amount unknown) in a suicidal intent in chronic depression
- On admission the patient had plasma levels of creatine kinase (CK) of 32,383 U/L, myoglobin > 3,000 µg/L, CRP 48 mg/L and exhibited a drastically increased CK level > 127,100 U/L (out of range) the next day, indicative for a drug-induced rhabdomyolysis
- Patient was at any time hemodynamically and respiratory stable, renal function tests remained consistently within the normal range
- Fluid Administration as well as of 8.4% sodium bicarbonate solution (~ 500 ml/day) to prevent myoglobin precipitation in the renal tubuli level
- Due to massive elevation of serum CK and myoglobin very quick decision to use CytoSorb in combination with renal replacement therapy with the rationale for the treatment of rhabdomyolysis-associated complications even before acute renal failure could establish

Treatment
- Three consecutive CytoSorb treatments for a total treatment time of 72 hours (24 hours each)
- CytoSorb was used in conjunction with a Octo Nova CRRT machine (Diamed; used hemofilter APS-18H from Asahi Kasei Medical Co., Ltd)
- Anticoagulation: heparin (PTT guided administration)
- CytoSorb adsorber position: pre-hemofilter

Measurements
- Rhabdomyolitic parameters (CK, myoglobin)
- Inflammatory parameters (CRP)
Results

- After the last treatment CK plasma concentrations were at 51.111 U/L, myoglobin 1.045 µg/L, both continuing to decline.
- While receiving treatment, there were no signs of acute renal failure at any time, the patient always showed good excretion and normal creatinine levels.

Patienten Follow-Up

- In the further course creatine kinase (4.695 U/L) and myoglobin levels (936 µg/l) continued to decrease.
- Patient could be discharged in completely stable condition within a few days directly from intensive care to her home environment.

CONCLUSIONS

- The CytoSorb therapy proved as highly efficient in terms of the elimination of CK and myoglobin in this patient.
- According to the medical team, such patients with such a pronounced rhabdomyolysis are usually transferred to a university hospital, however due to the rapid response to CytoSorb therapy this was not necessary in the present case.
- An acute renal failure could be prevented by the early combined use of CytoSorb and renal replacement therapy.
- Safe, simple and extremely practical application of CytoSorb especially with the Octo Nova machine.
Use of CytoSorb in mitral- and aortic valve endocarditis

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This case study reports on a 63-year-old male patient with mitral and aortic valve endocarditis, who underwent two cardiac surgeries for valve replacement.

Case presentation
- The patient had already been treated in the cardiological intensive care unit for 17 days due to a Staph aureus sepsis
- Due to a florid mitral valve endocarditis with large vegetations (2x2 cm in size) and consecutive mitral regurgitation as well as relevant risk of embolism, the decision was made to perform mitral valve replacement
- Even prior to admission to the cardiosurgical operating theatre, the patient was already in dialysis-dependent renal failure, required low-dose vasoconstrictor support and was tracheostomized due to long-term ventilation
- Relevant secondary diagnoses: IDDM, previous history of atrial flutter
- During mitral valve replacement on cardiopulmonary bypass patient had high demand for vasoconstrictor support with norepinephrine, yet still displayed ongoing and insufficient perfusion pressures, even post cardiopulmonary bypass (a hyperdynamic circulatory situation)
- After transfer to the anaesthesiology ICU the patient exhibited signs of peripheral circulatory failure. Echocardiography confirmed hypovolemia and pulse contour analysis showed reduced peripheral vascular resistance
- Therapy was extended to vasopressin and hydrocortisone, and later to epinephrine
- After 48 hours with increasing hemodynamic stabilization, the vasopressin and epinephrine were discontinued, and norepinephrine reduced.
- A follow-up echocardiography showed that the mitral valve prosthesis was functionally regularly, however, there was a high-grade aortic regurgitation with suspicion for endocarditic vegetations and massive calcification of the non-coronary sail
- On postoperative day 5 the patient underwent a second cardio-surgical revision followed by aortic valve replacement

Treatment
- In total two treatments with CytoSorb – treatments were performed postoperatively after mitral valve replacement (=1st treatment for 24 hours) and intra- and postoperatively during/after the aortic valve replacement procedure (=2nd treatment for 24 hours)
- CytoSorb was used in conjunction with CRRT (Multifiltrate, Fresenius Medical Care) performed in CVVHD mode
- Anticoagulation: citrate
- CytoSorb adsorber position: pre-hemofilter

Measurements
- Hemodynamic parameters and demand for catecholamines
- Inflammatory parameters (PCT, IL-1 beta, IL-6, IL-8, IL-10, IL-17, TNF alpha)
Results

- During the first treatment no relevant changes in hemodynamics were observed.
- Of the inflammatory mediators analyzed, the course of IL-6 showed a significant reduction when compared to the time prior to therapy initiation.
- The 2nd treatment, beginning with the revision surgery (aortic valve replacement) was associated with a hemodynamically and inflammatory stable course.
- The catecholamine demand remained virtually unchanged when comparing the intra- and postoperative with preoperative levels, hemodynamically there was no occurrence of vasoplegia, no significant increase in inflammatory mediators, and clinically no SIRS symptoms could be observed.

Patienten Follow-Up

- The further stay in the anesthetics ICU proved stable, especially in the light of his pre-existing multi-organ failure.
- The longer-term follow-up care was carried out by the coronary care unit.
- The patient unfortunately died three weeks after his aortic valve replacement due to a repeated multiple organ failures.

CONCLUSIONS

- Lack of hemodynamic effects after the first treatment with CytoSorb may have been due to the delayed start of treatment (postoperatively) as well as the pre-existing and long-lasting inflammatory condition of the patient.
- The early use in acute endocarditis (early intraoperative start during the 2nd surgery) could possibly have contributed positively to the clinical course of the patient in terms of potential suppression of recurrence of an inflammatory surge, which might have helped stabilize the inflammatory and hemodynamic situation.
- Treatment with CytoSorb was safe and easy to use.
Use of CytoSorb in hepatic encephalopathy

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This case study reports on a 58-year-old female patient (condition post pancreatectomy after ethyltoxic pancreatitis), who presented to the hospital for a routine imaging investigation due to a drainage problem of her bilio-digestive anastomosis, which had been installed a few years earlier.

Case presentation
- On presentation the patient was alert and responsive, however it was noted that she had consumed large amounts of alcohol in the period prior to admission
- During the following days after diagnostic imaging, the patient deteriorated dramatically and had to be transferred to ICU on day 12 with severe pneumonia
- Patient was intubated, ventilated, moderately catecholamine-dependent and in an unexpectedly poor general physical condition, without significant reconvalescence
- Microbiological findings showed infection with E. coli, so there was immediate initiation of antibiotic therapy with Piperacillin/Tazobactam, later on Imipenem, after which her pneumonia improved considerably over the next days, as confirmed radiologically
- Operation with installment of a new biliodigestive anastomosis
- Postoperatively prolonged recovery. During the first weaning attempts the patient remained relatively unresponsive and was not vigilant for weeks despite spontaneous breathing
- Determination of plasma ammonia levels showed a significant increase of up to > 230 µg/dl (normal range 19-87 µg/dl), other liver function tests also showed a moderate hepatic impairment – cholinesterase > 1500 U/l, gammaGT at 602 U/l, PDR 12.2%/min (normal range 18-25), R15 16% (normal range 0-10), Quick 60%, CRP also low with 48 mg/l
- In this phase the patient received a low-dose norepinephrine infusion (<0.5 mg/h)
- In the further course she suffered recurrent bouts of pneumonia and CVC infections
- Conservative lactulose therapy (orally or as an enema) and selective intestinal decontamination proved unsuccessful
- Due to the extremely high plasma ammonia levels (> 230 µg/dl), the decision was made to use CytoSorb as adjunctive therapy

Treatment
- Two treatments with CytoSorb, 1st treatment for 72 hours with significant reduction of ammonia levels to 66 µg/dl, thereafter treatment pause for 11 days during which ammonia levels rose back to 116 µg/dl, 2nd treatment for 72 hours
- CytoSorb was used in conjunction with CRRT (Multifiltrate, Fresenius Medical Care) performed in CVVHD mode
- Blood flow rate: 120 ml/min
- Anticoagulation: citrate
- CytoSorb adsorber position: pre-hemofilter

Measurements
- Ammonia
- Inflammatory parameters (CRP)
Results

- CRP continuously low between 40-50 mg/l during both treatment cycles
- After the first treatment reduction of ammonia to 66 µg/dl, rebound to 116 µg/dl during the 11 day treatment pause period, during the 2nd treatment ammonia could be reduced to 76 µg/dl
- Reduction of gammaGT in the course of the first treatment to 313 U/l, after treatment 2 there was no further reduction
- Patient improved significantly during the first CytoSorb treatment, and started to respond specifically and follow instructions; with increasing ammonia levels after the first treatment the patient was again somnolent, however during the 2nd treatment cycle she improved again, thereafter ammonia levels remained at a low level over the next weeks

Patienten Follow-Up

- Patient could be weaned off the ventilator 6 days after the second CytoSorb treatment
- Termination of renal replacement therapy immediately post second CytoSorb use
- After further improvement, patient could be mobilized whilst still in ICU
- Due to recurrent infections and lung problems, therapy was discontinued 50 days after the initial admission and the patient died

CONCLUSIONS

- CytoSorb represents a good and practicable treatment option for patients with high ammonia levels
- According to the medical team and since the treatment of this patient, the use of CytoSorb is now considered in patients with liver resection and post-operative hepatic dysfunction
- Treatment with CytoSorb was safe and easy to apply
Combination of ECMO and cytokine adsorption therapy for severe sepsis with cardiogenic shock and ARDS due to Panton-Valentine leukocidin-positive Staphylococcus aureus pneumonia and H1N1

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This case study reports on a 33-year-old previously fit female (5-month post-partum), who presented to the local emergency department following a 4-day history of flu-like symptoms with breathlessness, delirium, chest, and abdominal pains

Case presentation
- On the initial assessment, she was pyrexial, tachypneic, tachycardic, and hypotensive with cool peripheries
- Examination and investigations revealed clinical evidence of severe acute respiratory failure with extensive air space shadowing throughout with hypoxemia and metabolic acidosis (pH 7.1, lactate 5 mmol/l, base deficit -11 mmol/l)
- Cardiac assessment by transthoracic echocardiography revealed severe left ventricular failure with a left ventricular ejection fraction (LVEF) of 5–15 %
- Furthermore, she was severely neutropenic (white blood cell count 0.6x10⁹/l, neutrophils 0.3 x10⁹/l)
- She rapidly deteriorated requiring intubation and mechanical ventilation and treatment was initiated for community acquired pneumonia
- In addition, she required significant amounts of vasopressor and inotropic support to achieve an adequate mean arterial pressure, highlighting the central cardiovascular involvement in her critical state
- In view of clinical deterioration and cardiovascular and respiratory instability, she was transferred to the hospital of the authors for ongoing care and consideration of extracorporeal life support
- On arrival, she had severe respiratory failure with a Murray score of 3.7 (PaO₂ /FiO₂ ratio 11.1 kPa, PEEP 12, compliance 32 ml/cmH₂O, four-quadrant infiltration on chest radiograph)
- She was hypotensive with a MAP of 50 mmHg, despite high-dose infusions of norepinephrine (1–1.5 µg/kg/min) and vasopressin 0.04 U/h in addition to dobutamine 7.5 µg/kg/min
- Transthoracic echocardiography revealed a severely impaired, non-dilated left ventricle and normally functioning, non-dilated right ventricle
- There was metabolic acidosis (base deficit -6 mmol/l, lactate 4 mmol/l) and oliguria
- Care was initially supportive comprising mechanical ventilation, titration of high-dose inotropic and vasopressor agents, fluids, and continuous veno-venous hemodiafiltration
- She was treated empirically for severe sepsis and community acquired pneumonia and influenza. Subsequent analysis of sputum from direct bronchoscopy showed a heavy growth of Staphylococcus aureus (S. aureus) positive for expression of Panton–Valentine leukocidin (PVL). Viral PCR was also positive for H1N1 Influenza A. Clindamycin was added and intravenous immunoglobulin G (IVlg) therapy was commenced.
- In view of the severity of the combined respiratory and cardiac failure and evidence of worsening organ function, peripheral veno-arterial (VA) extracorporeal membrane oxygenation (ECMO) was instituted within 5 h of arrival and in view of the severe sepsis and high amount of vasopressors, CytoSorb was added to the hemofilter circuit

Treatment
- CytoSorb was added to the CVVH circuit (Prismaflex, Gambro, Sweden) and run parallel to the VA-ECMO circuit (Thoratec Centrimag pump at 4 L/min with inspired oxygen through the Medos hilite 700LT oxygenator set at 100%)
- Run time: One treatment session for 24 h
- Anticoagulation: Heparin, targeting activated partial thromboplastin time (aPPT) of 60–80 s
- Adsorber position: pre-hemofilter
Measurements

- Hemodynamics, inotropes and vasopressors doses
- Neutropenia and CRP levels
- Lactate

Results

- There was an improvement in oxygenation and gradual resolution of lactic acidosis after institution of the therapies
- Most notably, the initially very high doses of vasopressors could be weaned off after 12 h and she had no requirement for catecholamine support by 24 h
- The neutropenia also fully recovered to normal by day 2 and the serum C-reactive protein level reduced
- There were no adverse events related to the treatment

Clinical course of the first 24 h, showing doses of inotropes and vasopressors after starting ECMO and CytoSorb therapies. Doses are in µg/kg/min (adrenaline and noradrenaline); units/h (vasopressin)

Patienten Follow-Up

- ECMO therapy was continued for a total of 9 days
- At the time of ECMO removal, lung compliance and oxygenation (PaO2/FiO2 ratio) had improved significantly; however, hypercapnia remained a problem. To facilitate removal of carbon dioxide and to allow ongoing protective mechanical ventilation, a less invasive mode of extracorporeal lung support was established using the Hemolung RAS (ALung Technologies, Pittsburgh, USA) remaining in place for 5 days without complication
- A percutaneous tracheotomy was performed on day 12
- Despite chest CT showing evidence of cavitating, necrotizing pneumonia, lung function continued to improve
- The tracheal cannula was removed on day 23 and the patient was discharged to the ward on day 30
- She was reviewed in the follow-up clinic 2 months later and was well, with normal heart function on echocardiography
- Her lung function was reduced (FEV1 60 %, FVC 56 %, TLCO 55 %), but she has remained asymptomatic

CONCLUSIONS

- This case is the first report of the successful use of extracorporeal support and CytoSorb hemoadsorption therapy in combination to treat a patient with severe acute respiratory failure, septic, and cardiogenic shock due to PVL-S. aureus superinfection with H1N1
- The authors state, that the reversal of septic shock, the rapid weaning off of the high-dose vasopressor infusions as well as the quick resolution of neutropenia and reduction in CRP levels are unusual for such severe presentation, and that they feel that CytoSorb was a beneficial factor in the combination therapy with ECMO therapy
- This case report also demonstrates that multiple extracorporeal technologies, including VA ECMO, hemofiltration, and hemoadsorption with CytoSorb can be successfully combined in severe septic shock with myocardial involvement
CytoSorb in postoperative sepsis after aortic valve replacement

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This case study reports on a 73-year-old female patient who presented at the hospital for elective aortic valve replacement due to combined aortic valve vitium with predominant stenosis.

Case presentation
- Uncomplicated intraoperative course with subsequent transfer to the cardiosurgical intensive care unit and further transfer to intermediate care the next day
- However, on the same day the patient was transferred back to ICU due to pericard tamponade followed by immediate re-thoracotomy
- Postoperative initiation of CVVHD for fluid balance control due to oliguria and central congestion
- Postoperative a persistent fistula of the lung developed due to preexisting emphysema with subsequent revision by mini-thoracotomy 9 days after the first thoracotomy
- This was followed by a period of relative clinical and hemodynamic stability when the patient attempted to mobilize and began eating
- 5 days after the lung surgery an acute abdomen developed based on an obstructive ileus (a previous condition post appendectomy from several years previously)
- Patient had to have an emergency intubation for surgery, during which she aspirated
- She then had an emergency laparotomy with resolution of the obstructed ileus and installation of a double-barreled transversostomy
- Noradrenaline was required postoperatively at 2 mg/h, CRP significantly increased with 13.2 mg/dl, PCT only increased moderately at 0.4 ng/ml
- This was followed by rapid respiratory deterioration and development of aspiration-associated pneumonia with immediate initiation of treatment in accordance with the sepsis bundle and installation of veno-venous ECMO
- Start of calculated anti-infective therapy with Piperacillin/Tacobactam and on the following day with Levofloxacin. In the further course confirmation of Candida glabrata and Stenotrophomonas maltophilia in the tracheal secretions. As a result, extension to Cotrimoxazole (following resistogram) and due to absence of clinical improvement to Anidulafungin
- Withdrawal of blood cultures and repeated proof of Candida glabrata in blood cultures Diagnosis: Candida glabrata sepsis
- Because of acute renal failure and due to multiple conditions (lung surgery, long stay on the ICU, suspected aspiration pneumonia and assumed septic course) CytoSorb therapy was started simultaneously with the installation of the veno-venous ECMO (pre-emptive use)

Treatment
- Six consecutive CytoSorb treatment sessions for 24 hours each with a total treatment time of 144 hours
- CytoSorb was used in conjunction with citrate dialysis (Multifiltrate; Fresenius Medical Care) in CVVHD mode
- Blood flow rate: 100-180 ml/min
- Anticoagulation: citrate
- CytoSorb adsorber position: pre-hemofilter

Measurements
- Need for catecholamines
- Inflammatory parameters (PCT, CRP)
Results

- After the first treatment there was already a significant reduction in CRP - within 6 hours after the start of CytoSorb, CRP decreased to 8.2 mg/dl. 24 hours after initiation of treatment, CRP was 5.7 mg/dl. However, despite continuing the therapy over the next 5 days, there was a temporary rebound to 20.7 mg/dl followed by another decrease.
- PCT remained low over the entire treatment period, however it increased greatly after discontinuation of CytoSorb therapy to levels of 5.4 ng/ml.
- Norepinephrine could be significantly reduced during the first treatment (1.1 mg/h after 6 hours, 0.6 mg/h after 15 hours) with a tendency to further declining doses. Immediately after stopping CytoSorb therapy, physicians noticed a sharp increase back to 1.1 mg/h with further continuing high levels.
- Antibiotics dosages were not adjusted under CytoSorb therapy.

Patienten Follow-Up

- No further need for revision of the abdomen.
- Transfer to a respective center for further ECMO weaning.
- Confirmation of pronounced small intestine ischemia from abdominal CT, relating to a NOMI (non-occlusive mesenteric ischemia) with preexisting mesenteric vessel stenoses.
- All further therapy modalities were withdrawn and the patient died.

CONCLUSIONS

- In this multi-morbid patient with a diagnosis of Candida glabrata sepsis with already a very high chance of mortality, the preemptive use of CytoSorb showed an acute beneficial effect.
- Despite treatment with sufficiently high doses of anidulafungin the patient showed persistently detectable Candida in her blood cultures which resulted in an immediate septic exacerbation and clinical deterioration after discontinuation of CytoSorb treatment.
- There was effective clinical stabilization and consolidation of hemodynamics and inflammatory mediators under CytoSorb.
- Application of the CytoSorb adsorber in a pre-hemofilter position was simple, safe and without problems.
Use of CytoSorb in a case of acute septic cholecystitis due to E.coli sepsis

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This case study reports on a 65-year-old male patient (preexisting comorbidities chronic alcohol abuse, fibromyalgia), who was admitted to the emergency department via ambulance transport due to severe pressure pain in the right upper abdomen.

Case presentation
- Ultrasound examination showed an enlarged gallbladder with stones, however no dilated bile ducts; no increase in transaminases; hepatic parenchyma, spleen and kidney without pathological findings
- Diagnosis: acute cholecystitis
- Admission to surgical ward and initiation of antibiotic therapy with cefuroxime
- In the following night, the emergency medical team was alerted due to hypotension and increased respiratory rate
- Instantaneous transfer to ICU with diagnosis septic shock
- Blood cultures immediately withdrawn after ICU admission confirmed E. coli and Klebsiella oxytoca bacteremia, resulting in immediate switch of antibiotic regimen to Piperacillin/Tazobactam
- At this point of time the patient exhibited severe impairment of hemodynamics (norepinephrine 1.2 µg/kg/min), oliguria (<700ml/24h), acute liver dysfunction (INR 2.0; NH4- 69 µmol/l), increased retention parameters (creatinine 172 µmol/l, urea 7 mmol/l), metabolic acidosis (pH 7.12, lactate 11 mmol/l, base excess -20) as well as increased markers of inflammation and infection (CRP 182 mg/l, PCT 8.4 µg/l, leukocytes 57.8 E9/l, thrombozytes 92 E9/l)
- Installation of a gallbladder drainage
- Initiation of renal replacement therapy 5 hours after admission to ICU
- Despite adequate vasoconstrictor and fluid resuscitation and treatment according to the sepsis bundle, there was no noticable clearance of lactate
- Due to hemodynamic instability, the non-response to conventional treatment, acute renal and liver failure as well as metabolic acidosis with severely impaired lactate clearance, CytoSorb therapy was commenced in the further course
- Final diagnosis: acute septic cholecystitis

Treatment
- One treatment with CytoSorb for a total treatment time of 24 hours
- CytoSorb was used in conjunction with CRRT (Multifiltrate, Fresenius Medical Care) performed in CVVHD mode
- Blood flow rate: 100-130 ml/min
- Anticoagulation: citrate
- CytoSorb adsorber position: pre-hemofilter

Measurements
- Demand for catecholamines
- Renal function (creatinine, urea, excretion)
- Liver function (INR, NH4)
- Inflammatory parameters (CRP, PCT)
- Metabolics (Lactate, base excess, pH)
Results

- Hemodynamic stabilization with significant reduction of catecholamine dosages – after 24 hours of treatment norepinephrine requirement at 0.23 µg/kg/min - thereafter infusion in minimal doses - 36 hours after termination of the adsorber therapy norepinephrine could be completely tapered off
- After treatment the patient was still oliguric, however there was a significant drop in retention parameters (creatinine at 82 µmol/l, urea at 3.8 mmol/l)
- Liver function: One day after after discontinuation of treatment INR was at 1.6 and NH4 at 32 µmol/l
- Inflammatory parameters: PCT dropped to 5.6 ng/ml, CRP levels after treatment slightly higher at 195 mg/dl
- Lactate after treatment at 1.9 mmol/l, base excess at -3, pH back to a normal level (7.44)

Patienten Follow-Up

- Termination of renal replacement therapy 2 days after CytoSorb treatment with spontaneous diuresis
- Development of a critical illness delirium
- Patient stayed on ICU for a total of 7 days, followed by a stay on the surgical ward for another 2 weeks and final discharge of the patient directly to his home environment

CONCLUSIONS

- Treatment with CytoSorb was accompanied by an unexpectedly rapid and significant stabilization of hemodynamics and declining catecholamine dosages within hours
- Metabolic acidosis improved, also liver dysfunction parameters and PCT declined during combined CRRT/CytoSorb therapy. As a result, the patients status stabilized quickly.
- Safe and easy application of CytoSorb
Use of CytoSorb in decompensated alcoholic steatohepatitis

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This case study reports on a 36-year-old patient (chronic viral hepatitis C, longtime chronic alcohol abuse up to the point of admission to hospital), who was transferred an external hospital with decompensated cirrhosis.

Case presentation

- Direct admission of the patient to the intensive care unit with an initial diagnosis of decompensated ethanol toxic liver cirrhosis
- At this point the patient was hypotonic, tachycardic, in cardiogenic shock, oliguric, with upper gastrointestinal bleeding and a MELD score of 40
- Development of hepatic encephalopathy
- Attempt to stabilize the patient using albumin infusion and multiple paracenteses
- Hepatorenal syndrome due to decompensated cirrhosis and subsequent dialysis dependency
- Portal vein thrombosis was excluded
- Consequently the patient was treated for more than a month in the intensive care unit to stabilize the cirrhosis and acute kidney injury
- During this time, an evaluation as to whether the patient could be listed for a liver transplantation or not was rejected by the Liver Board due to the ongoing alcohol abuse up to the point of admission to ICU
- Since no transplant option existed, physicians continued therapy with available treatment options. The patient received a steroid therapy with 40 mg per day, however this did not result in any significant improvement
- Plasma bilirubin concentrations showed a significant increase of up to 24.5 mg/dl, ammonia levels were 130 µg/dl, albumin was 2.4 g/dl
- In addition, transaminases (GOT 259 U/L, GPT 59 U/L) as well as µGT (352 U/L) were markedly elevated
- Markers for spontaneous coagulation at this time were also poor with a Quick of 26%, Antithrombin III of 49%, PTT 42, INR 2.87
- Inflammation markers were: leukocytes 43,000/µl, CRP low at 3.46 mg/dl, and IL-6 42 pg/ml
- During this phase, the patient received a low-dose norepinephrine infusion (<0.025 µg/kg/min)
- As a „last resort“ therapy, CytoSorb treatment was also started with the rationale to remove inflammation-triggering factors and liver toxins (bile acids, bilirubin, ammonia) in the context of his systemic inflammatory condition as well as his acute-on-chronic liver failure
- Subsequent final diagnosis: Liver cirrhosis and alcohol-related steatohepatitis (ASH) with pre-existing hepatitis C infection

Treatment

- In total two treatments with CytoSorb were carried out, 1st treatment for 6 hours, followed by a treatment pause for 5 days to wait for the therapy effect due to non-existing evidence in this kind of patients, 2nd treatment for 6 hours
- 1st CytoSorb was performed in conjunction with CRRT (Multifiltrate, Fresenius Medical Care) performed in CVVHDF mode, 2nd treatment was performed in hemoperfusion mode
- Blood flow rate: 200 ml/min
- Anticoagulation: heparin
- CytoSorb adsorber position: pre-hemofilter
Measurements

- Ammonia (pre/post adsorber)
- Bilirubin
- Bile acids (pre/post adsorber)
- Inflammatory parameters (IL-6, CRP, leucocytes)

Results

- After the first treatment ammonia reduced to 88 µg/dl. During the 2nd treatment ammonia levels were measured pre and post adsorber: pre-adsorber 89 µg/dl - directly post adsorber 70 µg/dl; two hours later and also during treatment 2 ammonia levels pre-adsorber were 76 µg/dl and directly post adsorber 60 µg/dl, patient significantly improved both during and after the treatment sessions
- Reduction of bilirubin in the course of the first treatment from 24.5 mg/dl to 16.3 mg/dl after 4 hours (thereafter no further reduction, probably due to saturation of the adsorber), between the 1st and 2nd treatment bilirubin rose to 31.5 mg/dl. During the 2nd treatment session levels reduced again to 25.9 mg/dl within 4 hours
- Measurement of bile acids pre and post adsorber during the 2nd treatment were as follows: pre-adsorber 145 µmol/l – directly post-adsorber 119.7 µmol/l
- Increase of IL-6 during the first hour of the first treatment to 255.7 pg/ml (suspected catheter-associated infection, however with no subsequent successful pathogen detection), in the further course during the first treatment reduction to 33.5 pg/ml, no more valid measurement performed during 2nd treatment
- Leucocytes continuously reduced during both treatments to 20,000/µl after the first and 15,000/µl after the second treatment
- CRP was continuously low between 2-4 mg/dl during both treatment cycles
- During the first treatment, renal function and thus diuresis improved rapidly, so that CVVH could be discontinued after the first treatment

Patienten Follow-Up

- Termination of renal replacement therapy directly after the first CytoSorb session with stable diuresis and stable creatinine
- Patient initial clinical recovering with planned discharge to his home environment due to the lack of a transplant option
- Subsequent development of a nosocomial pneumonia, after which the patient went into another episode of fulminant pneumogenic sepsis and died on IMC three weeks after the last CytoSorb treatment

CONCLUSIONS

- CytoSorb represents a good and viable treatment option for patients with alcoholic steatohepatitis (ASH) and may be especially effective in young patients with severe inflammatory response in the context of their ASH
- CytoSorb worked extremely well and effectively as a liver replacement in this case, hepatic encephalopathy improved significantly due to removal of liver toxins
- In addition, measurement of pre/post adsorber values indicates that the removal of ammonia and bile acids is directly attributable to the adsorber
- According to the medical team, the impressive course of the patient has led to the initiation of a specific study project for such patients
- The installation of the absorber into the CVVH circuit and the application of CytoSorb itself was easy and safe
Extracorporeal hemocorrection in patients with acute kidney injury and severe cardiac insufficiency

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This case study reports on two patients with contrast-induced nephropathy (CIN; induced by usage of contrast cardiovascular system radiologic imaging) and severe cardiac insufficiency (NYHA IV) after undergoing coronary angiography (acute coronary syndrome, Killip IV).

Case presentation

- Due to chronic cardiac insufficiency in the setting of ischemic heart disease (functional Class 3-4) and the administration of contrast agent symptoms of acute kidney injury occurred 6 hours after the procedure.
- Both patients were hypervolemic (CVP 18±1.2 mmHg, ELWI 15±1 ml/kg)
- Left ventricular ejection fraction (LVEF) decreased to 34±3% while respiratory index was at 250±15
- This condition required artificial lung ventilation, renal replacement therapy and intensive catecholamine support
- Due to clinical need for renal replacement therapy, elevated levels of inflammatory markers, and high need for catecholamines CytoSorb was additionally installed into the CRRT circuit

Treatment

- CytoSorb was used in conjunction with a common dialysis machine (Multifiltrate; Fresenius Medical Care) run in CVVHDF mode
- Ultrafiltrate volume was 2,500-3,000 ml per day
- CytoSorb adsorber position: pre-hemofilter

Measurements

- Demand for catecholamines
- Hemodynamics (MAP, cardiac index, GEDVI, ITBVI, EVLWI)
- Inflammatory parameters (IL-6, IL-8, TNFα)
- Renal function (creatinine, urea, electrolytes)
Results

- Hemodynamics considerably improved during the course of the combined treatment; catecholamine support could be stopped while cardiac index increased by 30%, hypervolemia could be clearly reduced (CVP 8-9 mmHg, ELWI 8±1 ml/kg), left ventricular myocardial contractility improved with the ejection fraction increasing to 45%
- Respiratory index also increased to 390±15 mmHg
- Markers of inflammation could be significantly reduced: IL-6 and IL-8 decreased by 64% and 72%, respectively, TNFα decreased by 48% during the course of the treatment

Patienten Follow-Up

- By day 3 of extracorporeal hemocorrection urine output restored, renal retention parameters decreased
- After 7 days on ICU both patients were discharged to further therapy

CONCLUSIONS

- Extracorporeal hemocorrection methods (CytoSorb + CRRT) in patients with contrast-induced nephropathy and cardiogenic shock in the setting of acute cardiac insufficiency (NYHA IV) could be viewed as an effective therapy method
CytoSorb in peritonitis after perforation and pronounced SIRS

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This case study reports on a 63-year-old grossly obese (BMI 37) female patient who was admitted to the emergency department with an acute abdomen and signs of shock (tachycardia, hypotension).

Case presentation

- Patient had a preexisting incisional hernia in the lower abdomen following gynecological surgery several years before
- On the day of admission the patient immediately underwent surgical procedure (laparotomy, adhesiolysis, lavage, ileum resection, hernia sac resection, appendectomy)
- Preoperative commencement of antibiotic treatment with ampicillin/sulbactam and metronidazole, which was extended to imipenem on postoperative day 2 after microbiological findings from the intraoperative smear were available
- Postoperatively, the patient was directly transferred to ICU, ventilated and catecholamine-dependent
- On day 1 postop, patient developed significant capillary leak syndrome with high volume requirement (hematocrit of 44.7% could not be decreased despite volume administration of 6 liters/11 h and positive fluid balance, and was even trending upwards)
- In addition, the patient developed a severe SIRS accompanied by rapidly increased plasma levels of IL-6 (3,625 pg/ml), PCT (10 µg/l) and leukocytes (21,000/µl)
- Hemodynamic instability with need for high doses of norepinephrine (4.5 mg/h) and concomitant Mean Arterial Pressure of 67 and tachycardia (rate 150)
- Patient developed acute oliguric kidney failure with increased retention parameters (creatinine 149 µg/l, urea 8.2 mmol/l) and progressively declining diuresis of 150 ml in the first 12 hours of her ICU stay
- Pronounced lactic acidosis (5.4 mmol/l)
- Patient received hydrocortisone 200 mg/24h continuously without bolus
- Due to the significant capillary leak syndrome despite high fluid supplementation and due to the unabated rise in the need for catecholamine support, CytoSorb therapy was started 12 h after admission to ICU
- Microbiological findings on the 2nd postoperative day: E.coli, Enterococcus faecalis, Enterococcus faecium, Streptococcus salivarius, Bacteroides vulgatus
- Subsequent final diagnosis: perforated ileitis

Treatment

- Two consecutive CytoSorb treatment sessions (1st session for 24 hours, 2nd session for 30 hours)
- CytoSorb was used with machine type BM11/BM14 (Baxter), while the first treatment session was carried out in hemoperfusion mode only and the 2nd session in combination with CVVHF
- Blood flow rate: 200 ml/min
- Anticoagulation: heparin
- CytoSorb adsorber position: pre-hemofilter
Measurements

- Hemodynamics and demand for catecholamines
- Capillary leak syndrome (fluid requirement)
- Inflammatory parameters (PCT, leucocytes, IL-6)
- Renal function (excretion, retention parameters)
- Lactate clearance

Results

- With installation of the adsorber the norepinephrine dose could be significantly reduced (dose before treatment 4.5 mg/h, reduction to 2.5 mg/h after the 2nd treatment, one day later to 1 mg/h, the day thereafter 0.5 mg/h, the following day norepinephrine could be completely tapered off)
- Tachycardia as an expression of her inflammation-associated cardiomyopathy could be normalized (after 48 h heart rate was at 130 bpm and at 110 bpm upon completion of CytoSorb therapy)
- Clear containment of capillary leak syndrome: volume requirement (i.e. net fluid supply) decreased rapidly during the course of the two treatments (1st day of treatment 12 liters, 2nd day of treatment 8 liters and 4.5 liters on the day after the end of the 2nd treatment)
- Significant reduction in inflammatory parameters during the two treatment sessions: IL-6 109 pg/ml after the first treatment and 10 pg/ml after the second treatment, PCT 11.7 ng/ml after the first and 6.5 ng/ml after the second treatment, leucocytes 32,000/µl after the first treatment and 33,000/µl after the second treatment, on the following day leucocytes then fell to 19,000/µl with further decreasing levels thereafter
- Already in the first 12 hours of the first CytoSorb treatment (without CVVHF), diuresis rapidly increased to 570 ml, during the 2nd treatment with combined CVVH/CytoSorb therapy diuresis progressively improved further
- Antibiotic dosages did not have to be adjusted at any time

Patienten Follow-Up

- Extubation on postoperative day 7
- 4 days after extubation, the patient developed a delirium, which then normalized over the following days with appropriate treatment
- Transfer to surgical ward 11 days after initial admission and discharge to her home environment 4 days later

CONCLUSIONS

- Rapid application of CytoSorb led to a clear stabilization and consolidation of hemodynamic and inflammatory parameters, as well as significant containment of capillary leak syndrome within 48 hours
- The early application of the procedure may therefore have prevented the onset of additional organ failure
- The application of CytoSorb therapy was simple, safe and with no problems installing the adsorber in a post-hemofilter position
CytoSorb in severe sepsis following peritonitis in chronic ulcerative colitis

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This case study reports on a 77-year-old male patient (known pre-existing conditions: ulcerative colitis, Parkinson’s disease, diabetes mellitus, arterial hypertension, hypothyroidism) who was admitted to the emergency department with ileus symptoms and recurrent vomiting.

Case presentation

- Admission to the department of internal medicine and 2 days later presentation at the surgical department
- Patient was surgically treated for incipient peritonitis in known ulcerative colitis (laparotomy, sigma-resection, Hartmann surgery)
- Postoperatively, the patient was directly transferred to ICU in septic shock, ventilated and catecholamine-dependent
- Sharply increased inflammatory parameters (PCT 96.7 µg/l, CRP 460 mg/l)
- Initiation of antibiotic therapy with Tazobactam (later change to Linezolid and Meropenem), as a consequence inflammatory parameters clearly decreased (PCT 13.5 µg/l, CRP 280 mg/l) and hemodynamics stabilized (norepinephrine 0.25 µg/kg/min)
- 9 days after the surgical intervention occurrence of a second inflammatory surge with an increase of PCT to 163 µg/l and CRP to 400 mg/l as well as hemodynamic instability with need for high norepinephrine doses of up to 1.8 µg/kg/min
- Pronounced lactic acidosis (4.6 mmol/l)
- Initiation of PICCO-guided hemodynamic volume management
- Re-laparotomy with insertion of a retroperitoneal drain due to a suspected abscess
- Development of anuric acute renal failure (creatinine 115 µmol/l) despite administration of high amounts of fluids
- Due to his acute anuric renal failure and the recurring acute inflammatory response, physicians decided to initiate CytoSorb as adjunctive therapy together with CVVHDF
- Subsequent final diagnosis: severe sepsis following peritonitis caused by migration of gut bacteria in chronic ulcerative colitis

Treatment

- Two consecutive CytoSorb treatment sessions for a total treatment time of 10 hours (1st session for 7 hours, 2nd session for 3 hours)
- CytoSorb was used in combination with CRRT (Prismaflex, Gambro) run in CVVHDF mode
- Blood flow rate: 130 ml/min
- Anticoagulation: citrate
- CytoSorb adsorber position: post-hemofilter
Measurements

- Hemodynamics and demand for catecholamines
- Inflammatory parameters (PCT, CRP)
- Lactate clearance

Results

- During the course of the two treatments there was a temporary improvement in the systemic vascular resistance index (SVRI) from 900 to 1500 dyn*s/cm5*m2, however there was an continuing high demand for norepinephrine
- Clear reduction of inflammatory parameters under CytoSorb therapy (PCT 46 µg/l, CRP 257 mg/l)
- Stabilization of lactic acidosis
- Antibiotic dosages did not have to be adjusted at any time

Patient Follow-Up

- While still under maximum therapy there was a manifestation of an asystole, as a consequence and in agreement with the next of kin further resuscitation attempts were omitted and the patient eventually died

CONCLUSIONS

- The use of CytoSorb in this patient was a last resort decision and may have resulted in a better outcome of the patient if applied earlier (at best as he started to deteriorate or at the time of the re-occurrence of the second inflammatory surge)
- According to the medical team, from this time on CytoSorb is always considered and applied in cases of severe sepsis with concomitant severe inflammatory reactions (even if renal function is good)
- The application of CytoSorb therapy was simple, safe and with no problems installing the adsorber in a post-hemofilter position
CytoSorb in severe sepsis following rectal necrosis

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This case study reports on an 81-year-old male patient (history of asthma, arterial hypertension, aortic valve insufficiency, polymyalgia rheumatica) who was admitted to hospital with acute abdominal pain.

Case presentation

- Immediate admission to ICU and initiation of antibiotic therapy with cefuroxim/metronidazole. At this time the patient was hypotensive and had a CRP plasma level of 314 mg/l
- The same day an abdominal CT was performed, however no evidence of a perforation was found
- During the following hours the patient developed signs of sepsis, with hyperlactatemia (3.36 mmol/l) and could not be adequately stabilized
- Subsequent explorative laparotomy revealed rectal necrosis of unclear origin and the patient underwent rectal and partial sigmoid resection
- Postoperatively, the patient was directly transferred to ICU in septic shock, ventilated and extremely hemodynamically unstable with high requirement for norepinephrine (1.6 mg/h)
- He also showed increased plasma levels of inflammatory parameters (PCT 29 ng/ml, CRP 480 mg/l that continued to trend upwards, thrombocytes 119,000/µl, leucocytes 11,000/µl)
- Pronounced lactic acidosis (3.6 mmol/l), base excess -8.5
- Change of antibiotic therapy after the OR to Tazobactam/Piperacillin, which was then switched to an prolonged infusion protocol when CRRT was started (12 g/24 h)
- Development of anuric acute renal failure (creatinine 254 µmol/l, urea 16.6 mmol/l)
- Due to his acute anuric renal failure and condition of septic shock physicians decided to initiate CytoSorb as an adjunctive therapy together with CVVHDF
- Subsequent final diagnosis: sepsis due to rectal necrosis

Treatment

- Two consecutive CytoSorb treatment sessions for a total treatment time of 48 hours (24 hours each)
- CytoSorb was used in combination with CRRT (Multifiltrate, Fresenius Medical Care) run in CVVHDF mode
- Blood flow rate: 100 ml/min
- Anticoagulation: citrate
- CytoSorb adsorber position: pre-hemofilter
Measurements

- Hemodynamics and demand for catecholamines
- Inflammatory parameters (PCT, CRP)
- Lactate clearance

Results

- During the course of the two treatments there was a clear stabilization of hemodynamics, infusion rate of norepinephrine after 24 hours of treatment was 0.8 mg/h, and after 48 hours of CytoSorb therapy norepinephrine could be completely weaned off
- Clear reduction in inflammatory parameters under CytoSorb therapy (after 24 h of treatment: CRP 332 mg/l, PCT 16 ng/ml; after 48 h: CRP 182 mg/l, PCT 7.6 ng/ml; thereafter both parameters trended towards normal levels, thrombocytes: decreased to 78,000/µl within 48 h and bounced back to 130,000/µl two days after discontinuation of CytoSorb therapy
- Stabilization of lactic acidosis (lactate after 24 h of treatment: 1.57 mmol/l, after 48 h 1.04 mmol/l)
- Antibiotic dosages did not have to be adjusted at any time

Patient Follow-Up

- Extubation on day 3 of CRRT
- Reestablishment of spontaneous diuresis on the 4th day followed by discontinuation of CRRT and discharge to the normal ward
- 2 days after discharge from ICU the patient developed bleeding problems with need for a re-laparotomy where the source of the bleeding was found
- Thereafter readmission to ICU for another 2 days, however with no further problems, he was discharged to normal ward and later discharged to home in good health

CONCLUSIONS

- Clear stabilization and consolidation of hemodynamics and inflammatory mediators under CytoSorb within 48 hours
- According to the medical team CytoSorb should always be considered and applied in the early phase of septic shock
- The application of CytoSorb therapy was simple, safe and there were no problems installing the adsorber in a pre-hemofilter position
CytoSorb in severe septic shock after colon perforation

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This case study reports on an 82-year-old male patient (medical history: previous myocardial infarction, arterial hypertension, coronary heart disease, aneurysm, atrial fibrillation with oral anticoagulation, diabetes mellitus) who presented at the hospital with an acute abdomen after he had undergone an outpatient colonoscopy where he was found to have a suspicious (malignant) stenotic process in the ascending colon.

Case presentation

- Admission to the surgical ward and initiation of preoperative intestinal preparation (administration of rinsing solution) for elective laparotomy
- Meanwhile dramatic acute deterioration in his general condition and development of a circulatory insufficiency as well as of an ileus
- Transfer to intensive care unit for further monitoring
- In the following 12 hours development of an acute abdomen accompanied by full-blown septic shock and immediate initiation of an emergency laparotomy
- Already preoperative commencement of antibiotic therapy with ceftriaxone 1x2g, ampicillin 3x2g, metronidazole 3x 500 mg (24 hours later change to imipenem 4x500 mg)
- Intraoperative diagnosis of an intestinal gangrene above the stenotic process as well as an intestinal wall rupture with resulting peritonitis
- Operative treatment by means of extended right hemicolectomy
- Postoperatively, the patient was readmitted to ICU in septic shock, mechanically ventilated, catecholamine-dependent and with multi-organ failure
- Laboratory values showed greatly deranged inflammatory parameters with leukopenia 1.5 Gpt/l, CRP 250 mg/l, PCT 101 ng ml and severe lactic acidosis (12 mmol/l)
- Hemodynamic instability with increased doses of noradrenaline (0.8 μg/kg/min)
- Development of anuric renal failure (creatinine 160 μmol/l, urea 6.3 mmol/l) despite extensive volume resuscitation (fluid balance +16 liters in the first 24 hours) and subsequent initiation of renal replacement therapy
- Upon connection to the dialysis machine patient had a cardiac arrest with pulseless electrical activity (PEA) followed by a 5-minute cardiac massage
- In addition, establishment of liver failure: ALT 4140 IU/l, AST 6180 IU/l, Quick 35%, ATIII 28 %, platelets 30 Gpt/l, GGT 2219 IU/l
- Initiation of PICCO-guided hemodynamic volume management
- Due to the multi-organ failure (mainly kidney, liver) and as a last resort therapy option the decision was made to incorporate CytoSorb as adjunctive therapy in addition to renal replacement therapy

Treatment

- Two consecutive CytoSorb treatment sessions for a total treatment time of 48 hours (both sessions for 24 hours)
- CytoSorb was used in combination with CRRT (Prismaflex, Gambro) run in CVVHDF mode
- Blood flow rate: 130 ml/min
- Anticoagulation: citrate
- CytoSorb adsorber position: post-hemofilter

Measurements

- Hemodynamics and demand for catecholamines
- Inflammatory parameters (PCT, CRP, leucocytes)
- Lactate clearance
- Markers of liver failure (ALT, AST, GLDH)
Results

- Noradrenaline doses could be significantly reduced during the first treatment (0.42 μg/kg/min after 24 hours) and were almost tapered off after 48 hours (0.05 μg/kg/min).
- This was accompanied by an improvement in cardiac index from initially 2.4 l/min/m² to 3.6 l/min/m² and a clear improvement in the systemic vascular resistance index (SVRI) from 520 to 2600 dyn*s/cm⁵*m² during the course of the 2 treatments.
- Clear reduction in the inflammatory parameters under CytoSorb therapy: PCT after 24 hours at 57 ng/ml and after 48 hours at 23.8 ng/ml, CRP after 48 hours at 200 mg/l, leucocytes after 48 hours at 8.9 Gpt/l.
- Stabilization of lactic acidosis - after 24 hours lactate was 8 mmol/l, after 48 hours 6.2 mmol/l, after 4 days normalization of plasma lactate levels.
- Significant improvement in liver function associated with a decrease in transaminases: after 48 hours ALT 312 IU/l, AST 84 IU/l and GLDH at 381 IU/l with complete normalization of all parameters after 4 days.
- Antibiotic dosages did not have to be adjusted at any time.

Patienten Follow-Up

- Termination of renal replacement therapy 7 days after completion of CytoSorb treatment.
- Transfer to normal ward 58 days after the last absorber use with normal renal values.
- In the further course of his postoperative stay in intensive care unit, development of wound healing disorders of the abdominal wall and successful closure using vacuum-assisted closure therapy.
- Transfer to neurological rehabilitation with Critical Illness Polyneuropathy and Critical Illness Myopathy.
- 4 months after the procedure discharge from rehabilitation to his home environment with good neurological outcome.

CONCLUSIONS

- Impressively rapid reversal of shock with rapid stabilization of hemodynamics and a prompt reduction in catecholamine doses.
- According to the medical team, the effect of reversing liver failure was particularly impressive, especially as patients with this manifestation of liver failure usually die.
- This case using CytoSorb showed a very good outcome, resulting in the fact that the adsorber is now used much more regularly in patients with septic shock in the department.
- The application of CytoSorb therapy was simple, safe and with no problems installing the adsorber in a post-hemofilter position.
Use of CytoSorb in necrotizing fasciitis and severe septic shock

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This case study reports on a 53-year-old male patient (previous medical history: arterial hypertension, DM II, COPD, bipolar affective disorder) who was admitted to hospital with a suspected acute scrotal erysipelas.

Case presentation
- Admission to the dermatological department with additional presentation to the urological department
- One day after admission rapid deterioration of the general condition with presentation at the urological department and immediate referral for surgical procedure (radical inguinal-rectal fasciotomy of Fournier gangrene and necrotizing fasciitis)
- Additional need for cardiopulmonary resuscitation whilst still in the operating room and installation of a temporary pacemaker
- Postoperative transfer to the intensive care unit in very severe septic shock with multi-organ failure (renal insufficiency, vasoplegia, hemodynamic instability, septic cardiomyopathy), ventilated, under volume therapy, catecholamine-dependent
- Highly elevated inflammation parameters (PCT 35.81 ng/ml, leukocytes 37,500/μl, CRP 35.8 mg/dl) and greatly impaired renal function (GFR of 8.8 ml/min)
- Antibiotic therapy initially with piperacillin + tazobactam as well as clindamycin, after microbiological findings, plus micafungin
- Short-term stabilization under conventional therapy, however, due to his acute renal insufficiency as well as the hemodynamic instability and the increased inflammation markers, the decision was made to initiate CytoSorb as adjunctive therapy together with a CVVHD

Treatment
- One treatment with CytoSorb for a total treatment time of 24 hours
- CytoSorb was used in conjunction with CRRT (Multifiltrate, Fresenius Medical Care) performed in CVVHD mode
- Blood flow rate: 150 ml/min
- Anticoagulation: citrate
- CytoSorb adsorber position: pre-hemofilter
Measurements

- Demand for catecholamines
- Renal function (GFR, excretion)
- Inflammatory parameters (CRP, PCT, leucocytes)

Results

- Hemodynamic stabilization with a significant reduction in catecholamine doses - norepinephrine from initially 0.3-0.91 μg/kg/min to 0.09-0.2 μg/kg/min within the first 24 hours, patient was free from catecholamines 48 hours after completion of CytoSorb treatment
- Clear reduction in inflammatory parameters under CytoSorb therapy (CRP 10 mg/l, leukocytes 22,500/μl, PCT 7.39 ng / ml)
- Clear improvement in renal function: GFR from 8.8 to 26.6 ml/min within 4 days

Patient Follow-Up

- Daily surgical wound care, disinfection, removal of necrotic tissue
- Termination of renal replacement therapy 3 days after CytoSorb application with complete recovery of diuresis 13 days later
- Weaning and extubation successful 11 days after CytoSorb application
- In the days post extubation, the patient presented as clinically stable, was awake, adequately alert, mentally appropriate and was able to tolerate complete oral nutrition
- 26 days after the use of CytoSorb the patient was discharged to the urological ward with a VAC system

CONCLUSIONS

- Treatment with CytoSorb was accompanied by an unexpectedly rapid and significant stabilization in vital functions (renal function, hemodynamics) as well as declining catecholamine doses within a few hours
- According to the medical team, the rapid start of treatment with the combination of CytoSorb and CVVHD may have saved the patient's life
- The installation of the absorber into the CVVH circuit as well as the application of CytoSorb itself was simple and safe
Use of CytoSorb in ethyltoxic liver failure and hepatic encephalopathy

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This case study reports on a 62-year-old male patient (previous medical history of liver cirrhosis Child-Pugh B, arterial hypertension, long-term alcohol abuse with previous withdrawal attempts), who was admitted to hospital via emergency ambulance with suspected ethyltoxic liver failure.

Case presentation

- Admission to the internal ward
- 2 days later transferred to the intensive care unit due to the development of hepatic encephalopathy (ammonia 229 μmol/l) as well as extremely high bilirubin values (> 600 μmol/l), parameters of cholestatics and transaminases (GGT 4620 U/l, ALT 89 U/l, AST 332 U/l)
- Spontaneous breathing with adequate gas exchange
- Normal coagulation parameters
- Kidney function also normal: spontaneous diuresis 1800 ml/6h
- Patient catecholamine-free at all times
- No antibiotic therapy necessary
- Initiation of a liver supportive co-medication: L-ornithine-L-aspartate 3x 5g daily, human albumin (20%) 3x50 ml daily, vitamin B1 1x 100 mg daily as a short infusion, ACC 2x 300 mg daily, additional subcutaneous anticoagulation with Fondaparinux 1x 2.5 mg daily
- Initial care with Central Venous Catheter, arterial catheter and Shaldon-catheter
- A combination treatment with CVVH and CytoSorb was commenced 6 hours after transfer to ICU with the rationale to avoid kidney failure and to relieve the liver

Treatment

- In total seven treatments with CytoSorb were run (treatments 24 hours each)
- CytoSorb was used in conjunction with CRRT (Multifiltrate, Fresenius Medical Care) performed in CVVHD mode
- Blood flow rate: 100-120 ml/min
- Anticoagulation: citrate
- CytoSorb adsorber position: pre-hemofilter
Measurements

- Ammonia
- Markers of cholestasis and liver failure (ALT, AST, GGT, total bilirubin)
- Inflammatory parameters (CRP)

Results

- CRP continuously low between 20-30 mg/l during all treatment cycles

<table>
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</table>

Patient Follow-Up

- On the 5th day in ICU, X-ray diagnosis confirmed pneumonic infiltrates, which could however be well controlled with a course of Rocephin 1x 2g daily as a short infusion
- Termination of renal replacement therapy together with the last CytoSorb treatment followed by a 2-day polydiuretic phase
- Intensive care for another 2 days
- Transfer to internal ward
- 3 days later transfer to a peripheral facility for extended alcohol withdrawal
- Significant reduction in hepatic encephalopathy, patient was more alert, hemodynamically stable and with sufficient spontaneous diuresis

CONCLUSIONS

- Rapid and clear reduction in hepatic encephalopathy using CytoSorb therapy
- Combined CVVH/CytoSorb therapy resulted in a significant decrease in bilirubin and a concomitant decrease in the parameters of cholestasis as well as in transaminases, which is a clear sign of recovery in hepatic function
- After cessation of CVVH/CytoSorb therapy, bilirubin levels increased, however ALT, AST and GGT remained low and further decreased also suggesting the recovery of liver integrity
- CytoSorb represents a good and practicable treatment option for patients with high levels of ammonia and bilirubin in order to facilitate relief and ultimately regeneration of the liver (function)
- According to the medical team and since the treatment of this patient, the use of CytoSorb is now being considered in patients with developing or already manifest liver failure
- There was no clotting of the system over the entire treatment period
- Treatment with CytoSorb was safe and easy to apply
CytoSorb in rhabdomyolysis of unclear origin

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This case study reports on a 21-year-old male patient who was admitted to hospital via emergency ambulance with a suspected generalized epileptic seizure, after he accidentally fell in the bathroom and was subsequently found groaning in bed with retrograde amnesia.

Case presentation

- Direct admission to the neurological ward (stroke unit)
- At this time the patient was asymptomatic with normal renal function (creatinine 97 μmol/l, GFR 84.2 ml/min, urea 4.4 mmol/l), but he already had a slightly increased creatine kinase (CK) of 488 U/l (CK-MB proportion 28 U/l)
- On day 3 after admission creatine kinase increased to 82,491 U/l (CK-MB proportion 434 U/l)
- The patient was then referred to the cardiology department with suspected cardiac infarction and laboratory data were again taken. These showed a severe deterioration in the renal function (creatinine 447 μmol/l, GFR 14.4 ml/min, urea 11.8 mmol/l) and a further increase in the creatine kinase level to 90,713 U/l (CK-MB proportion 485 U/l)
- Patient was transferred to the internal intensive care unit and plasma myoglobin levels were determined (> 3000 μg/l)
- Despite highly elevated rhabdomyolysis parameters, the patient was still clinically asymptomatic, hemodynamically and respiratory stable, awake, responsive, and after a vigorous fluid administration there even was a temporary recovery of diuresis
- Repeated blood tests indicated established renal failure (creatinine at 417 μmol/l, GFR of 15.7 ml/min, urea 11.3 mmol/l, but no signs of hypercalcemia or of acidosis), and also a noticeable impairment in the liver function (LDH 2051 U/l, GOT 510 U/l) with ongoing elevated rhabdomyolysis parameters (creatine kinase at 82,552 U/l (CK-MB portion 512 U/l), myoglobin> 3000 μg/l)
- Due to his massive rhabdomyolysis and concerns of sustained renal damage as well as the presumption that a conservative forced diuretic therapy (with Na-bicarbonate, furosemide & volume) might work too slowly, CytoSorb was initiated simultaneously with renal replacement therapy

Treatment

- 3 CytoSorb treatment sessions for a total of 60 hours (1st treatment 20 hours, 2nd treatment 24 hours, 3rd treatment 15 hours)
- CytoSorb was used in conjunction with CRRT (Octonova; Diamed) in CVVHD mode
- Blood flow rate: 200 ml/min
- Anticoagulation: heparin
- CytoSorb adsorber position: post-hemofilter
Measurements

- Rhabdomyolysis parameters (creatine kinase, myoglobin)
- Renal function (GFR, creatinine, urea)
- Markers of impaired liver integrity (LDH, GOT)

Results

- The first measurement about 2 hours after initiation of therapy showed a reduction in the plasma concentration of CK to 79,086 U/l (CK MB content 527 U/l), stable myoglobin (> 3000 μg/l) and LDH values (2253 U/L), and a slight improvement in renal function (creatinine 325 μmol/l, GFR 20.9 ml/min)
- 9 hours after the start of therapy, renal function had recovered further (creatinine 219 μmol/l, GFR 32.9 ml/min, urea back within the normal range), however there was an increase in CK to 85,131 U/l (CK MB content 243 U/l), myoglobin 1400 μg/l and a further improvement in renal function and retention parameters (GFR 46.9 ml/min, creatinine 161 μmol/l)
- 6 hours after the start of the second treatment, CK values could be further decreased to 38,234 U/l (CK MB portion 249 U/l), and after another 9 hours of running time to 24,680 U/l (CK MB portion 171 U/l)
- At this time hepatic (LDH 418 U/l, GOT 310 U/l) and renal function (creatinine 125 μmol/l, GFR 62.9 ml/min) also improved markedly
- After completion of the 15-hour (3rd) therapy session CK was 8965 U/l (CK MB proportion 72 U l), myoglobin 1,117 µg/l, and LDH of 255 U/l
- Only 1.5 hours after completion of the 3rd CytoSorb treatment, the renal function had already started to deteriorate again (creatinine at 132 μmol/l, GFR 59 ml/min)

Patient Follow-Up

- Termination of renal replacement therapy together with the last CytoSorb treatment
- Further diuretic therapy with 40 mg/h of furosemide and continuously falling rhabdomyolysis parameters
- 3 days after the last CytoSorb treatment the patient was transferred to the peripheral internal-cardiology ward and later to a peripheral neurological ward. At this time CK levels were at 1325 U/l, myoglobin 151 μmol/l, and GFR at 50 ml/min
- A progressive thrombocytopenia developed during the CytoSorb-/CVVHD-treatment session (thrombocytes dropped from 209,000/µl to a minimum of 82,000/µl).
- From the laboratory values there was no evidence for haemolysis, heparin-induced thrombocytopenia nor for thrombotic microangiopathy
- After termination of CytoSorb-/CVVHD-therapy thrombocytes spontaneously reversed to normal values
- The following picture emerged during search for the final diagnosis: Screening for antibodies (ANA, pANCA, cANCA, dsDNA) - negative, drug screening in urine - negative, alcohol level - negative, screening for IgG, IgM (toxoplasmosis) – negative
- Screening for aldolase antibodies was positive
- Final diagnosis: Rhabdomyolysis of unclear origin (possibly indicative of an underlying muscular dystrophy disease (late type), which has to be confirmed by further tests

CONCLUSIONS

- According to the medical team, the patient benefited considerably from the combined CytoSorb/CVVHD therapy, rhabdomyolysis parameters could be significantly reduced and renal function was maintained. A purely conservative treatment might have led to a permanent impairment of renal function.
- Handling of the adsorber was easy and safe
Use of CytoSorb in severe sepsis after hemicolecction and anastomosis dehiscence

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This case study reports on a 80-year-old female patient (previous medical history of: arterial hypertension, coronary heart disease, atrial fibrillation, NIDDM II, aortic stenosis, peripheral vascular disease, chronic renal failure III), who was admitted to hospital for elective right-sided hemicolecction for colon carcinoma.

Case presentation

- Admission to normal surgical ward for scheduled operation and subsequent postoperative transfer to intensive care unit
- Her stay on ICU was complicated by secondary bleeding on the 1st postoperative day necessitating an immediate re-laparotomy with removal of hematoma
- After a short stay in ICU, transfer to the normal surgical ward for further treatment for a total of 10 days
- On the 10th day, acute deterioration of her general condition, diagnosis of severe sepsis after anastomosis dehiscence with fecal peritonitis
- Immediate surgical care with re-laparotomy, anastomotic resection, installation of a new anastomosis, lavage and drainage
- Antibiotic therapy initially with tazobactam/piperacillin and after microbiological findings were available, changed to meropenem/echocantine (gram-negative sepsis)
- 8 days later again deterioration with re-laparotomy and placement of a terminal ileostoma and abdominal dressing (VAC treatment for wound closure)
- Retransfer to ICU, orotracheally intubated, mechanically ventilated, noradrenaline-dependent with doses of 0.5-0.83 μg/kg/min at a heart rate of 90-140/min and a blood pressure of 80/45 mmHg, which improved to 110/60 mmHg with noradrenaline
- At this point she exhibited highly elevated inflammatory parameters (CRP 33.7 mg/l, leukocytes 28.400/μl, PCT 75 ng ml)
- Additional impairment of renal function: GFR 14.7 ml/min
- Due to her acute-on-chronic renal insufficiency as well as her hemodynamic instability and the increased inflammatory markers, the decision was made to initiate CytoSorb as an adjunctive therapy together with CVVHD

Treatment

- Two treatments with CytoSorb for a total treatment time of 66 hours (1st and 2nd treatment for 24 hours each, treatment pause of 18 hours between both treatments)
- CytoSorb was used in conjunction with CRRT (Multifiltrate, Fresenius Medical Care) performed in CVVHD mode
- Blood flow rate: 150 ml/min
- Anticoagulation: citrate
- CytoSorb adsorber position: pre-hemofilter
Measurements
- Demand for catecholamines
- Renal function (GFR, excretion)
- Inflammatory parameters (CRP, PCT, leucocytes)

Results
- Hemodynamic stabilization with a significant reduction in catecholamine doses – norepinephrine doses could be reduced to 0.09-0.2 μg/kg/min during both treatments, patient was free from catecholamines 96 hours after completion of both CytoSorb treatments
- Clear reduction of inflammatory parameters under CytoSorb therapy (CRP 10.38 mg/l, leucocytes 14,500/µl, PCT 22.5 ng/ml)
- Clear improvement in kidney function: GFR from 14.7 to 45.6 ml/min

Patient Follow-Up
- Termination of renal replacement therapy 2 days after the last CytoSorb treatment, recovery of diuresis to initial quantity 7 days after the last CytoSorb treatment
- Weaning and extubation successful 6 days after CytoSorb application
- 11 days after the CytoSorb application, the patient could be transferred to the normal surgical ward
- Over the following days the patient was clinically stable, awake, adequately alert, mentally appropriate, and with complete oral nutrition
- Final surgical healing successful following installation of a terminal ileostoma

CONCLUSIONS
- The treatment with CytoSorb resulted in stabilization of vital functions (improvement in the circulatory and renal function) as well as declining doses and finally complete cessation of catecholamines
- CytoSorb was safe and easy to use
A clinical experience of using extracorporeal cytokine adsorption device (CytoSorb) in a case of Dengue fever

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This case study reports on a 32 year old male patient who was transferred to tertiary ICU with worsening multi organ failure, after presenting to a local hospital with fever, chills, dyspnea, yellow discoloration of skin and sclera the previous week.

Case presentation
- On admission the patient was pyrexic (100°F, heart rate 120 – 130 bpm, respiratory rate 26 – 30 per min, leukocytosis 16,400 µl, with acute organ dysfunction (agitation, thrombocytopenia, hypoxia, kidney dysfunction, metabolic acidosis and arterial hypotension), sepsis and septic shock. His APACHE score on admission was 27.
- Within 24 hours the patient needed to be mechanically ventilated because of worsening Acute Respiratory Distress Syndrome (ARDS) and hypoxia.
- The patient received fluid optimization, nutritional support, antibiotics, proton pump inhibitors, treatments for hepatic encephalopathy, blood products and other standard support therapy.

Treatment
- CytoSorb was added as a supportive therapy due to the systemic inflammatory response and multiple organ dysfunction.
- The patient received three sessions of six hours each on days 2, 4 and 6 of admission.
- No anticoagulation was used, blood flow rate was 250 mL/min.

Measurements
- Clinical and laboratory parameters before and after CytoSorb treatment: Creatinine, hematocrit, leucocytes, platelets, mean arterial pressure (MAP), ARF - Acute Renal Failure, GCS - Glasgow Coma Scale, aPTT - Activated Partial Thromboplastin Time, GOT - Serum Glutamic Oxaloacetic Transaminase (AST), GPT - Serum Glutamic Pyruvic Transaminase (ALT).
- Arterial blood gas values before and after CytoSorb therapy: pH, PaCO₂ - Partial Pressure of Carbon Dioxide, PaO₂ - Partial Pressure of Oxygen, SBC - Standard Bicarbonate, (A-a) O₂ - Alveolar-arterial oxygen gradient mmHg, Base Excess.
Results

- There were no major complications during or after the CytoSorb therapy except mild irritability that settled with sedatives.
- Patient showed gradual improvement with APACHE score after the third cycle decreasing from 27 to 12.
- As a result of the treatment:
  - Creatinine decreased from 3.96 to 1.59 mg/dL
  - Leucocytes from 16,3000 to 13,000 /µL
  - Platelets from 50,000 to 311,000 /µL
  - GCS from 9 to >10
  - Mean arterial pressure from 84 to 104 mmHg
  - aPTT from 43 to > 60 seconds, GOT (AST) from 15690 to 156 U/L, GPT (ALT) from 3910 to 84 U/L
  - Serum lactate from 6.7 to 1.9 mmol/L

Post-treatment period and follow-up

- Patient was transferred from ICU on day 13, and subsequently discharged fully ambulant.

CONCLUSIONS

- CytoSorb helped to stabilize and revive this patient with dengue, MODS and shock.
- The majority of laboratory parameters were within the normal range after the therapy and no major adverse events were reported during or after the CytoSorb therapy.
- This is the first report of the clinical application of CytoSorb hemoadsorption in a case of dengue fever with MODS treated successfully with standard of care along with CytoSorb.
- CytoSorb seems to be an interesting and safe option to stabilize and help dengue patients with MODS to recover.
Hybrid blood purification strategy in pediatric septic shock

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2Department of Intensive Care, Hopital Erasme, Route de Lennik 808, 1070 Brussels, Belgium

This case study reports on a 12-year-old female patient with refractory septic shock (clinical history of acute lymphatic leukemia and recent chemotherapy) who was admitted to the emergency department because of fever and fatigue.

Case presentation

- In the emergency department, mean arterial pressure (MAP) was below 50 mmHg and did not improve after initial fluid resuscitation (20 ml/kg)
- Empiric antimicrobial therapy was initiated and the patient was admitted to the pediatric intensive care unit
- Because of severe persistent hypotension with arterial lactate concentrations of 74 mg/dl, epinephrine and norepinephrine were initiated at 0.2 μg/kg/min and 0.08 μg/kg/min, respectively
- Six hours after admission, the patient remained severely hypotensive (MAP of 45 mmHg) despite fluid and vasopressor therapy and low-dose hydrocortisone administration
- Later microbiological findings confirmed that blood cultures yielded Klebsiella pneumonia, related to a percutaneously inserted central line infection

Treatment

- In the absence of oliguria, continuous renal replacement therapy (CRRT) was started (CVVHDF modality; dialysate flow of 35–40 ml/kg/h) with a high cutoff (HCO) filter (Septex®) in combination with a CytoSorb cartridge

Measurements

- Vasopressor doses
- Lactate
- Procalcitonin
Results
- A significant reduction of vasopressor doses was observed 48 hours after the initiation of extracorporeal blood purification
- A similar positive trend was observed for lactate (74 vs 32 mg/dl) and procalcitonin (65 vs 18 ng/ml) concentrations
- The combined treatment was continued for 72 hours without adverse events

Post-treatment period and follow-up
- The patient was successfully discharged after 10 days.

CONCLUSIONS
- The combination of HCO-CRRT and CytoSorb might have had a synergistic effect in this setting; this association has not yet been explored in the treatment of pediatric septic shock
- The treatment with CytoSorb in this pediatric patient could be carried out for 72 hours without problems and proved to be well tolerated
- Further studies are needed to assess the feasibility as well as the optimal timing of initiation of such an approach in children suffering from septic shock.
Use of CytoSorb in a case of severe septic shock and septic cardiomyopathy due to urosepsis

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Hospital Martha-Maria Halle-Döblau, Department for Anesthesiology, Intensive Care Medicine and Pain Therapy

This case study reports on a 82-year-old male patient (medical history of chronic renal insufficiency stage 3, prostate carcinoma), who presented at the hospital for elective radical cystectomy with ileum conduit installation after pre-existing urothelial carcinoma and recurrent urinary tract infections with urinary congestion.

Case presentation

- Post-operative admission to Intermediate Care (IMC)
- Due to postoperative bleeding and subsequent hemorrhagic shock, the patient was taken back to surgery
- After reoperation, the patient was monitored in ICU for 4 days and then transferred to the normal urological ward
- 14 days later the patient was admitted back to the ICU in severe septic shock with hypotension, chills, ECG alterations and suspected myocardial infarction after he had undergone a routine ureter splint exchange on the previous day
- At this time, the patient already required high doses of norepinephrine (0.5 μg/kg/min), showed excessively high inflammatory parameters (IL-6 73,020 pg/ml, LBP 28.2 μg/ml, leukocytes 48,600/µl), impaired renal function (GFR at 30 ml/min, creatinine 179 μmol/l), an increased Troponin T high sensitivity (TroponinThs) of 0.096 ng/ml and an increase in CK-MB
- Immediate initiation of antibiotic therapy with imipenem, after E.coli was confirmed in the patients’ urine from the smear of the ureter splint exchange the previous day
- The decision was made to treat the NSTEMI (Non-ST-Segment Elevation Myocardial Infarction) conservatively with Clopidogrel and ASS anticoagulation, i.e. in his current critical state no coronary intervention (coronarography with possible stent installation) at this point in time
- Echocardiographic diagnosis confirmed severe aortic valve stenosis, which was probably only noticeable in the context of the septic cardiomyopathy and his impaired pump function
- Noninvasive ventilation, administration of 200 mg/24 h hydrocortisone
- Commencement of advanced hemodynamic monitoring with PICCO, which showed clear signs of volume overload with concomitant oliguria (in pre-existing chronic renal insufficiency)
- Further increase of lactate up to 5.1 mmol/l and of TroponinThs (1.2 ng/ml) as well as progressively increasing catecholamine demand (0.75 μg/kg/min)
- Initiation of renal replacement therapy with cautious ultrafiltration and simultaneous initiation of CytoSorb therapy

Treatment

- Three treatment cycles with CytoSorb for 24 hours each
- CytoSorb was used in conjunction with CRRT (Multifiltrate, Fresenius Medical Care) performed in CVVHD mode
- Blood flow rate: 125 ml/min
- Anticoagulation: citrate
- CytoSorb adsorber position: pre-hemofilter

Measurements

- Demand for catecholamines
- Renal function (creatinine, excretion)
- Inflammatory parameters (IL-6, leucocytes)
- Lactate
Results
• Norepinephrine after the first treatment was 0.3 μg/kg/min, and after the 3rd treatment was still 0.2 μg/kg/min, which was probably rather associated with the cardiac impairment, given the declining systemic inflammation response.
• Extremely efficient reduction of the initially high inflammatory parameters - IL-6 after the first treatment had already decreased to 687 pg/ml, after the second treatment 29.8 pg/ml and after the third treatment 40.8 pg/ml, with ongoing further decreases; normalization of LBP at 10.5 μg/ml during the course of the treatments; leucocytes initially increased to 87,000/μl after the first treatment, but then continued to fall over the following days to normal values.
• Continuously falling lactate levels with 2.3 mmol/l after the 2nd treatment and 1.2 mmol/l after the third treatment.
• Normalization of creatinine and GFR over the course of 3 treatments (after first treatment: creatinine 147 μmol/l, GFR 38 ml/min, after the 2nd treatment: creatinine 79 μmol/l, GFR 84 ml/min; after 3rd treatment: creatinine 102 μmol/l, GFR 60 ml/min).

Patient Follow-Up
• Termination of renal replacement therapy together with the last CytoSorb treatment after 3 days
• Patient remained stable and was transferred to the cardiology ward for further monitoring and for preparation for his aortic valve replacement (TAVI). Left ventricular ejection fraction was 25% at this time.
• Further course of treatment included several transfers from the cardiology ward to IMC and ICU for treatment of wound healing problems.
• Ultimately the patient was discharged to his home environment.

CONCLUSIONS
• Treatment with CytoSorb was accompanied by an unexpectedly rapid (within hours) and significant reduction in inflammatory parameters.
• It was the patients’ severe septic condition, the associated septic cardiomyopathy and the cardiac decompensation that revealed his aortic valve stenosis and made its diagnosis possible. According to the medical team, without the rapid control of the overwhelming inflammatory response and thus the prevention of manifest organ damage, the patient would not have survived to make it to the curative heart surgery and would have died with high probability.
• Safe and easy application of CytoSorb.
Use of CytoSorb in severe necrotizing ethyltoxic pancreatitis and ARDS due to bilateral pneumonia

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This case study reports on a 45-year-old patient (pre-existing diseases: arterial hypertension, steatosis hepatis, sigma diverticulosis, previous gastric ulcer, 20 year history of chronic alcohol consumption), who was admitted to the psychiatric clinic primarily for alcohol withdrawal after increased alcohol consumption in the previous month.

Case presentation

- Transfer of the patient to the intensive care unit (ICU) two days after initial admission with unclear abdominal symptoms and suspicion of pancreatitis (elevation of lipase to 1780 I/U)
- On admission, the patient had an APACHE 2 score of 28, severe SIRS, and acute renal failure
- The abdominal CT confirmed an extensive exudative pancreatitis, while the chest CT showed signs of beginning infiltrates and bilateral pneumonia
- Despite antibiotic therapy, as well as protocol-based volume therapy, there was increasing respiratory insufficiency, resulting in endotracheal intubation on the day of ICU admission after an unsuccessful initial attempt of non-invasive ventilation
- After 24 hours of (ineffective) maximum standard therapy and the onset of acute renal failure with anuria despite sufficient positive fluid balance, continuous renal replacement therapy was started in combination with CytoSorb (due to the protracted shock) in spite of therapy with dobutamine and adjunctive hydrocortisone

Treatment

- Four consecutive treatments with CytoSorb for a total duration of 72 hours (1st treatment: 24 hours, 2nd + 3rd treatment 12 hours each, 4th treatment: 24 hours)
- CytoSorb was applied in conjunction with CRRT (Multifiltrate, Fresenius Medical Care) run in CVVHD mode
- Blood flow: 100-150 ml/min
- Anticoagulation: citrate
- CytoSorb adsorber position: pre-hemofilter

Measurements

- Demand of catecholamines (dose of norepinephrine vs. the thereby achieved MAP)
- Creatinine
- Bilirubin
- Thrombocytes
- Lung function PaO₂/FiO₂
- SAPS 2 and SOFA
- Lactate
Results

- Shock-reversal after a total of 4 treatment cycles to <10% of the initial norepinephrine dose; i.e. after the end of the last CytoSorb treatment only 10% of the norepinephrine administration was still required - most probably due to the ongoing need for analgo-sedation. From day 10 the patient was catecholamine-free.
- Reduction of creatinine and bilirubin during the four treatment cycles. Bilirubin showed a rebound after the end of the last treatment.
- Dose adjustment of the calculated antibiotic therapy with high dose meropenem (4g/day) was not necessary.

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Patient Follow-Up

- Already during the initial treatment phase including cytokine adsorption, extracorporeal oxygenation with a Novalung X-Lung membrane became necessary and was continued for a total of 10 days due to ARDS (Horowitz index of 60). Due to severe multiple organ failure, a dilatation tracheotomy was performed during the course of the day and the patient was weaned from the respirator on day 15 of treatment after successful weaning from the ECMO. He was decannulated two days later.
- Pancreatitis resolved and the alcohol withdrawal was completed after 27 days in the intensive care unit.
- Hepatic function: ongoing increased bilirubin levels at the end of treatment and low platelets. However, plasmatic coagulation proved intact and the patient exhibited standard values on discharge.
- Further recovery was completed without complications. The patient was fully oriented at all times as well as hemodynamically stable. Clinically, there were sensitivity disorders in the patients’ hands and neuropathic pain in the area of the lower and upper thighs pointing towards critical-illness polyneuropathy.
- His arterial hypertension continued. So that the antihypertensive medication had to be adapted.
- The patient continued to improve. Was able to tolerate a normal diet and mobilization. And on the 27th day was discharged to the rehabilitation unit in good general condition.

CONCLUSIONS

- Treatment with CytoSorb became necessary for two reasons - on the one hand due to the severe necrotizing pancreatitis with severe SIRS/shock, and on the other hand also because of pneumonia with ARDS and septic shock, both of which resolved.
- Treatment with CytoSorb was safe and application possible without technical problems.
Use of CytoSorb in severe septic shock

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This case study reports on an 83-year-old female patient (pre-existing diseases: coronary heart disease, condition post LIMA on RIVA, long-QT-syndrome, intermittent atrial fibrillation, arterial hypertension, post hysterectomy and cholecystectomy), who was found at home by the emergency services after she had fallen and sustained a scalp laceration and multiple bleeding abrasions after a recent history of nausea, ‘slimy’ vomit, and weakness over the previous weeks.

Case presentation
- When found at home, the patient had a heart rate of 90/min and a blood pressure of 77/40 mmHg
- Immediate on-site administration of 500 mls of crystalloids i.v. and subsequent transfer and presentation to the Emergency Room
- On admission, the patient was cool and pale, hypotonic, slow to respond, with a respiratory rate of 33/min, pH 7.27 and lactate 9.5 mmol/l
- Administration of 1500 mls of crystalloids i.v., wound care and withdrawal of 2 blood cultures as well as start of antibiotic therapy with piperacillin/tazobactam
- Chest X-ray showed minor signs of emphysema, cranial CT was negative, and CT abdomen showed evidence of intra-hepatic cholestasis without clear cause, as well as sigmoid diverticulosis
- Laboratory values at this time: hemoglobin 7.3 mmol/l, leukocytes 18 Gpt/l, platelets 199 Gpt/l, PCT 12 ng/ml, Quick 60, bilirubin (total) 128 mmol/l, bilirubin (direct) 110 mmol/l, aspartate aminotransferase (AST) 2.89 mmol/l, alanine aminotransferase (ALT) 2.49 mmol/l, gamma-glutamyltransferase (GGT) 12.82 mmol/l, alkaline phosphatase 5.13 mmol/l, glomerular filtration rate (GFR) 28.9 ml/l
- Admission to Intermediate Care (IMC) and initiation of arterial pressure measurement and placement of a femoral central venous catheter (CVC)
- Despite volume replacement, rapidly increasing need for vasopressor therapy and persistant high lactate
- After a further 4 hours, transfer to the internal intensive care unit with diagnosis of septic shock (suspected abdominal focus) with an APACHE II score of 27, acute anuric kidney failure, early stage liver failure and suspected septic encephalopathy
- With further increases in volume requirements and ongoing anuria, initiation of renal replacement therapy (CVVHDF) and administration of dobutamine and levofloxacin
- On the following day suspicion of cholangitis so initiation of an emergency endoscopic retrograde cholangio-pancreatography (ERCP) with papillotomy (EPT) and insertion of a stent in the draining bile duct (DHC)
- Postoperatively elevated plasma levels of IL-6 (> 5000 pg/ml) and PCT (88 ng/ml)
- Initiation of advanced hemodynamic monitoring (PiCCO)
- Due to the presence of septic shock as well as acute renal failure, CytoSorb was added to the CRRT circuit 20 h after the initial ambulatory emergency treatment

Treatment
- One treatment with CytoSorb over a total treatment period of 24 hours
- CytoSorb® was applied in conjunction with CRRT (Prismaflex, Firma Gambro) run in CVVHDF mode
- Blood flow: 120 ml/min
- Anticoagulation: citrate
- CytoSorb adsorber position: post-hemofilter

Measurements
- Demand of catecholamines
- IL-6 and PCT
- Lactate
- Bilirubin
Results

- Hemodynamic stabilization with a clear reduction of norepinephrine doses from 0.4 μg/kg/min to 0.04 μg/kg/min and a complete cessation of catecholamines 24 hours later
- Clear reduction in inflammation-relevant parameters (IL-6 from >5000 to 268 pg/ml, PCT from 88 to 26 ng/ml) during the course of the treatment
- Normalization of the lactate plasma levels
- Significant reduction in plasma bilirubin levels from 128 to 28 μmol/l

Patient Follow-Up

- Ongoing abdominal pain associated with an increase in creatine kinase levels, clinical suspicion of colitis
- Colonoscopy showing sigma diverticulosis, mucosal bleeding in the ascending colon, ulcerative lesions in the rectum
- On the 3rd day proof of E. coli in the blood culture followed by deescalation of antibiotic therapy to Rocephin
- On day 4 successful extubation and another day with non-invasive ventilation
- On day 5 termination of CVVHDF as well as start of enteral nutrition via a nasogastric tube and transition to a normal diet
- Day 6-10: Polyuric phase, delirium, detection of critical-illness polyneuropathy followed by referral for rehabilitation
- Day 11: Normalization of retention parameters
- Day 12: Transfer of the patient to the normal ward for another 10 days where she was able to take some initial steps on the walking bench
- After 43 days the patient was able to be discharged from the rehabilitation clinic to her home environment without any deficits

CONCLUSIONS

- Clear stabilization and consolidation of hemodynamics and reduction of inflammatory mediators under CytoSorb within 24 hours in addition to standard therapy
- Regain of control of septic shock and decrease of plasma bilirubin levels within a short period of time
- The early start of CytoSorb therapy was possibly decisive for the good clinical course of the patient
- The application of CytoSorb therapy was simple, safe and without problems installing the adsorber in a post-hemofilter position
Pre-emptive use of CytoSorb during orthotopic cardiac transplantation

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This case study reports on a 50-year-old male patient who was hospitalized while awaiting elective orthotopic heart transplantation due to rapidly progressing end stage heart failure, after he had been treated for non-ischemic dilated cardiomyopathy for four years.

Case presentation

- More than 30 days continuous hospitalisation pre-transplantation due to decompensated heart failure.
- Pulmonary artery catheterization confirmed elevated PA pressure: 53/32(42) mmHg, PA wedge pressure: 31 mmHg, CO: 3.6L/min, CI: 1.73L/min/m² and PVR: 3.05WU.
- Despite maximally advanced conservative treatment, rapid progression of the heart failure developed 20 days before transplantation, including severely increased total body water content, reduced creatinine clearance of 56.0 ml/min/1.73m² (creatinine: 127 µmol/L), elevated gamma-glutamyl transpeptidase of 107 U/L and markedly limited exertion tolerance (New York Heart Association class D).
- Dobutamine infusion was started (up to 10 µg/kg/min) and the patient was referred to the Eurotransplant 'High Urgent' waiting list.
- After a period of 20 days on the 'High Urgent' waiting list a donor heart from a 52-year-old male beating-heart donor was offered (estimated transfer distance 1200 km), which was accepted for the patient.
- In spite of the negative results on the preoperative infection screening (white blood cell count: 8.0 Gpt/L, procalcitonin: 0.16 µg/L, C-reactive protein: 13 mg/L, negative microbiological tests and no clinical sign of active infection) a high perioperative inflammatory response was presumed based on factors such as the presence of immune priming (slightly elevated CRP caused by end stage heart failure), expected reperfusion injury due to prolonged low cardiac output state (>20 days), possible increased cold ischemic time of the donor heart (long transfer distance) and cardiopulmonary bypass time.
- To minimize the anticipated perioperative organ injury, as a consequence of the high inflammatory response and also potentially high dose of vasopressor requirements and to enhance the postoperative recovery of the patient, the pre-emptive intraoperative use of the CytoSorb was indicated.

Treatment

- One treatment cycle with CytoSorb during cardiopulmonary bypass (SORIN-Stöckert S5 Perfusion System, Sorin Group USA Inc).
- Blood flow: 400-500mL/min
- Anticoagulation: unfractionated heparin
- CytoSorb adsorber position: post-oxygenator

Measurements

- Postoperative inflammatory response: Procalcitonin (PCT), C-reactive protein, white blood cell count (first three days)
- Hemodynamic state: MAP, CI, SVRI, PVR (four time points in first 24 hours)
- Oxygenation: SvO₂, lactate (four time points in first 24 hours)
- Vasopressor requirements (first 72 hours) and the time of discontinuation
- Cardiac function: ejection fraction, LV, RV, TR, TAPSE (first five days)
- Renal and liver function: creatinine, bilirubin, INR, fibrinogen, AST, ALT (first 72 hours)
- Postoperative complications
- Clinical outcome parameters: time of extubation, length-of-ICU-stay, length-of-hospital-stay, 30-day-mortality
- Immunological outcome: rejection (first four endomyocardial biopsies)
Results

- The cold ischemic time of the donor heart was 288 minutes, the CPB time was 187 minutes.
- Patient required urgent reoperation within four hours after the transplantation due to surgical bleeding.
- The inflammatory response was remarkably mild as observed in the change in PCT, CRP and WBC during the first 72 hours (1.45-0.97-0.52 µg/L; 9.0-75.0-100.0 mg/L; 8.0-13.0-14.8 Gpt/L, respectively).
- There was a marked vasoplegia (SVRI: 1271±228 dyn*s/cm5*m2) during the first 24 hours, however, the vasopressor requirements were only moderate (noradrenaline: 0.11 µg/kg/min and terlipressin 0.9 µg/kg/h on average) to keep mean arterial pressure in the range of 72±5 mmHg. CI (4.0±0.7 L/min/m2) and PVR (1.46±0.46 WU) remained in the normal range.
- While lactate peaked at 6.5 mmol/L within 12 hours and normalized in the next 12 hours (2.5 mmol/L), SvO2 values confirmed sufficient oxygen delivery (72.0±2.6 %) in the first 24 hours.
- Noradrenalin and terlipressin could be reduced by 50% over the next 24 hours (0.05 µg/kg/min and 0.55 µg/kg/h, respectively) and were discontinued by the fourth postoperative day.
- There was no relevant decrease in cardiac function: EF: 62-65%; LV diameter: 44-47mm; RV diameter: 30-40; TAPSE: 7-11mm (min-max) based on the series of echocardiography performed during the first five postoperative days.
- Renal function remained well preserved (creatinine: 116-102-142 µmol/L), however, the biochemical parameters showed a moderate but transient reperfusion injury of the liver: bilirubin: 25-25-20 µmol/L; AST: 156-123-60 U/L; ALT: 92-45-36 U/L; INR: 1.7-1.3-1.3; fibrinogen: 2.1-2.5-3.3.

Patient Follow-Up

- Apart from a transient early cognitive dysfunction which delayed the patient’s extubation, we did not observe any severe organ dysfunction or infection in the postoperative period.
- Patient was ready for extubation after 38 hours of mechanical ventilation.
- An uneventful ICU treatment was completed on the ninth postoperative day and the patient was discharged to home relatively fit and well on post-transplant 22th day.
- The first four endomyocardial biopsies performed weekly excluded any grade of rejection.

CONCLUSIONS

- The pre-emptive intraoperative use of CytoSorb® resulted in considerably reduced inflammatory response and vasopressor requirements in contrary to expectations based on perioperative factors.
- Despite the patient’s poor preoperative condition, he experienced an uneventful postoperative course, free from any significant organ dysfunction.
- The unexpected ability to rapidly wean the vasopressors due to the stable hemodynamic state facilitated a fast recovery of the patient after heart transplantation.
- Safe and easy application of CytoSorb
Use of CytoSorb in septic shock after colon perforation and 4-quadrant peritonitis

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This case study reports on a 60-year-old female patient, who was hospitalized for elective debulking surgery after diagnosis of ovarian carcinoma (FIGO IV).

Case presentation
- Postoperative transfer to intensive care unit and 3 days later transfer to normal ward
- Deterioration in her general condition with development of an acute abdomen and relaparotomy 2 days later
- After relaparotomy re-admission to the intensive care unit with septic shock after colon perforation and 4-quadrant peritonitis
- At the time of admission, the patient had an APACHE 2 score of 30, severe septic shock with acute renal failure
- Despite antibiotic therapy (initially meropenem and then after 24h changed to piperacillin/ tazobactam according to antibiogram) as well as protocol-based volume therapy, the patient developed a highly catecholamine-dependent cardiac insufficiency with norepinephrine dosages of up to 38 µg/min
- Due to anuria despite sufficiently positive volume balance, CVVHDF therapy was initiated in conjunction with CytoSorb

Treatment
- Two treatments with CytoSorb for a total duration of 48 hours (24 hours each)
- CytoSorb was applied in conjunction with CRRT (Prismaflex, Gambro Hospal GmbH) run in CVVHDF mode
- Blood flow: 100-150 ml/min
- Anticoagulation: citrate
- CytoSorb adsorber position: post-hemofilter

Measurements
- Demand of catecholamines
- Parameters of infection (leucocytes, CRP, PCT)
- Creatinine
- SAPS 2
- Lactate
Results

- Shock-reversal after a total of 2 treatment cycles to <25% of the initial norepinephrine dose; further maintenance of norepinephrine infusion was necessary most probably due to the ongoing need for analgesedation. From day 5 the patient was catecholamine-free
- Significant reduction in inflammatory parameters with CytoSorb therapy
- Stabilization of lactate acidosis, after 3 days normalization of the plasma lactate values
- Dose adjustment of the antibiotic therapy was not necessary

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</tbody>
</table>

Patient Follow-Up

- Completion of renal replacement therapy 30 hours after cessation of CytoSorb treatment with normal renal clearance parameters
- During hospitalization, the patient developed a delirious syndrome, resulting in prolonged weaning
- During hospitalization the patient had to be tracheotomized
- During the recovery phases, the patient showed a left-sided hemiparesis. A CCT examination revealed the suspicion of meningeal suspensions in the context of metastases with brain swelling. However, the cerebrospinal fluid showed no malignant cells.
- Tracheal decannulation 28 days after the last application of Cytosorb
- Transfer to normal ward 30 days after the last CytoSorb treatment with normal renal values
- Discharge to geriatric rehabilitation 69 days after the last CytoSorb adsorber application

CONCLUSIONS

- Clear stabilization and consolidation of hemodynamics and inflammatory parameters under CytoSorb therapy within 48 hours
- The application of CytoSorb therapy was simple, safe and the installation of the adsorbers was possible without problems
The Use of a Cytokine Adsorber (CytoSorb) in a Patient with Septic Shock and Multi-Organ Dysfunction (MODS) after a Severe Burn Injury

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Handchir Mikrochir Plast Chir

This case study reports on a 21-year-old male patient, who was admitted directly to the hospital from an accident site after an explosion in the home environment with 2b-3-degree burns to 60% of his body surface area.

Case presentation
- Affected were both arms, face, thorax as well as both thighs
- Pre-existing diseases included known epilepsy and multifactorial drug abuse
- The ABSI score (abbreviated burn severity index) was 10 points
- On admission, immediate bath therapy was performed while the patient was still circulatory and hemodynamically stable, with a complete body shave/washing and surgical wound cleaning of the burned areas
- No trauma requiring surgical treatment was detected in the emergency trauma CT
- Bronchoscopy confirmed inhalation trauma grade II
- As a result of burns grade III, escharotomy was performed on both arms and thorax on the day of admission
- Multiple operations were carried out and later, also Meek-transplantations 1:6 on the lower abdomen, both upper arms, the upper thorax and both forearms
- Furthermore, residual necrotic tissue was removed predominantly from the back and face, using epifascial debridements
- There was a pronounced loss of transplant, as a result cultured keratinocytes (which were obtained early in advance) were used for restoration
- Due to the confirmed inhalation trauma grade II, a Rotorest bedding with dorso-ventral alternating bedding was carried out and an adaptation of the ventilation parameters was performed
- Due to persistently elevated inflammatory (leukocytes, C-reactive protein [CRP] and procalcitonin) and renal function parameters, positive blood cultures and wound smears confirming Acinetobacter baumannii 4MRGN [multiresistant gram-negative pathogen], hemofiltration therapy with additional integration of a CytoSorb adsorber was commenced

Treatment
- Application of CytoSorb from the 9th to the 17th day and from the 32nd to the 52nd day of treatment (28 cycles in total).

Measurements
- Demand for catecholamines
- Parameters of infection (IL-6, IL-10, CRP)
Results

- Interleukins IL-6 and IL-10 significantly reduced during treatment
- Demand for catecholamines was significantly reduced and hemodynamic stabilization could be achieved

Patient Follow-Up

- Due to the persistent infection with Acinetobacter baumannii, the patient was isolated in his therapy box and received an antibiogram-compatible therapy with colistin
- During his further hospitalization, the pulmonary and renal situation of the patient worsened drastically. Chest X-ray control confirmed bilateral pneumothoraces, which were drained
- In addition, regular X-ray controls showed the development of an ARDS [acute respiratory distress syndrome] with respiratory acidosis
- Due to the persistently poor respiratory situation, the medical team considered the use of ECMO [extracorporeal membrane oxygenation], which was rejected later after several conversations and at the request of the family as well as due to the bad prognosis
- The patient died on the 52nd postoperative day of cardiopulmonary insufficiency and multiorgan failure

CONCLUSIONS

- This is the first described case of a standard treatment with the CytoSorb adsorber as an adjuvant therapy for a burn patient with a septic episode
- CytoSorb therapy resulted in a significant reduction in inflammatory mediators (IL-6, IL-10) and catecholamines
- In this patient CytoSorb improved hemodynamics through the proven reduction of norepinephrine and had a significant impact on the survival time of this patient
- Treatment in this patient was safe and well tolerated
- By the early application of CytoSorb, the septic episode in burn patients can be potentially improved and the survival time can be prolonged
- Therefore, the reduction of inflammatory mediators such as cytokines and free hemoglobin by CytoSorb might be a promising approach
Hemoadsorption with Adult CytoSorb® in a Low Weight Pediatric Case - A Worldwide Premiere Procedure

Cirstoveanu C, Barascu I, Stancu A.
Case Rep Crit Care. 2017;2017:6987167

This case study reports on the case of a nine-month-old male infant who was admitted to the neonatal intensive care unit from the pediatric cardiovascular surgery unit, on his fourth postoperative day after the correction of tetralogy of Fallot.

Case presentation

- On the 3rd postop day the patient became febrile, so a complete blood count (CBC), biochemistry and a blood culture were performed. On day 4 he was admitted to the NICU gravely unwell, intubated and mechanically ventilated, with unilaterally diminished breath sounds, hypoxemia (oxygen saturation: 90%), oliguria, tachycardia (137 beats per minute), hypotension (74/44/59 mmHg) and abdominal distention with anasarca and fever (39-40°C). Physical examination revealed hepatosplenomegaly.
- CBC showed hemoconcentration (Hb: 14.2 g/dl, Ht: 45%), thrombocytopenia (27,000/mm³), neutrophilia (66.6%). Coagulation tests revealed a grossly elevated INR (4.66), hypofibrinogenemia (113 mg/dl) and a prolonged aPPT time (63 seconds). A severe inflammatory response (SIRS) was noted (CRP: 47.76 U/L, Procalcitonin: 10 ng/L). Liver function tests (LFTs) were greatly abnormal (ALT: 1883.1 U/L, AST: 4214.5 U/L, GGT 72 U/L, total bilirubin: 10.05 mg/dl, direct bilirubin: 7.59 mg/dl), consistent with hepatocellular necrosis.
- Renal impairment was evident with a creatinine of 1.15 mg/dl and urea of 55 mg/dl. Creatinine kinase and creatine kinase-MB were also elevated with values of 1619 U/L and 159.6 U/L, respectively. Acid-base balance was deranged (metabolic acidosis). Blood culture was sterile and the culture from tracheal aspirate revealed Escherichia coli.
- Meropenem, Vancomycin and Fluconazole were initiated. Multiple episodes of severe hypotension and bradycardia were treated with adrenaline, noradrenaline and dopamine. Due to persistent SIRS (CRP values from 47.76 to 54.76), antibiotics were changed to Tienam (Imipenem and Cilastin) and Amikacin.
- Two days after ICU admission oliguria rapidly evolved to anuria, and peritoneal dialysis was initiated. While the patient’s fluid intake continued to exceed the output the decision was made to start hemodiafiltration (HDF) (Prismaflex, Baxter). Throughout HDF, the patient continued to be hypotensive and brady cardiac necessitating in an increased dose of inotropic agents.
- Metabolic acidosis also persisted despite treatment, he continued to be thrombocytopenic requiring multiple thromocyte mass transfusions. He also developed macrocytic, hyperchromic anemia. After initiation of HDF he continued to be oliguric with intensely hyperchromic hematuria.
- As the patient continued to be febrile, antibiotic therapy was modified once more to Meropenem and Ciprofloxacin for a duration of 16 days. Antibiotic doses were kept constant throughout.
- Bilirubin levels kept increasing, culminating in a maximum value of 54 mg/dl of total bilirubin and 31.67 mg/dl of direct bilirubin. Intense scleral and cutaneous jaundice was observed and the patient was diagnosed with cholestatic jaundice.
- On the 9th day of continuous hemodialfiltration the therapeutic decision of commencing hemadsorption with a cytokine adsorber (CytoSorb) was taken

Treatment

- One treatment with CytoSorb for 49 hours
- CytoSorb was used in conjunction with CRRT (Prismaflex, Baxter) performed in CVVHDF mode
- Blood flow rate: 40 ml/min
- Because of the flow rate being so much slower that the recommended flow rate, the procedure was maintained for 49 hours
- Anticoagulation: heparin
- CytoSorb adsorber position: post-hemofilter
Measurements

- Demand for catecholamines (norepinephrine, dopamine, epinephrine)
- Ventilation settings (FiO₂, respiratory rate, positive end expiratory pressure (PEEP), positive inspiratory pressure (PIP))
- Bilirubin, transaminases

Results

- During the first 24-hour period with CytoSorb, total bilirubin value decreased from 54 to 17 mg/dl and the patient’s general status improved considerably. At the end of the 49 hours the total bilirubin was 14 mg/dl.
- The liver function (aminotransferases) also decreased rapidly but rose to their previous values as soon as CytoSorb® was removed.
- Noradrenaline decreased rapidly from 0.8 to 0.18 mcg/kg/min during the first 24 hrs and ceased within the next 24 hours. Dopamine decreased from 8 to 5 mcg/kg/min to 0 during liver support. The dose of adrenaline decreased within 48 hours of CytoSorb® treatment and ceased after 5 days.
- The patient’s ventilation settings also improved during CytoSorb treatment

Patient Follow-Up

- HDF was stopped after 11 days
- The patient’s cardiovascular status improved
- Diuresis gradually reached normal values and enteral nutrition could be initiated
- Quantitative renal function returned to normal as did renal function tests
- It was possible to keep the antibiotic doses constant during the entire CytoSorb procedure
- The patient was discharged home after 34 days of hospitalization, in good general status, hemodynamically stable, afebrile and weighing 9.6 kilograms
- He was referred to a pediatric neurologist for follow-up

CONCLUSIONS

- This is the first published case of CytoSorb used in a critically unwell 9 month old baby
- CytoSorb could be safely used in this pediatric case of septic multi-organ failure after cardiac surgery
- Both bilirubin levels and liver enzymes improved dramatically during CytoSorb use as did the patients hemodynamic and respiratory status
- Despite the fact that the flow rate was only 40mls / min (normally >100-150 mls/min), there were no instances of clotting in the adsorber
- Antibiotic doses could be kept constant during the entire hemoadsorption procedure using CytoSorb
Use of CytoSorb in necrotizing fasciitis and severe septic shock

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Sana Hospital Hameln-Pyrmont (Germany), Anaesthesiology and Intensive Care Medicine

This case study reports on a 57-year-old female patient (known pre-existing diseases: arterial hypertension, poorly adjusted diabetic mellitus type II, peripheral arterial vascular disease), who was admitted to the emergency department with symptoms of sepsis, somnolence, deranged blood glucose of 1000 mg/dl and lactate acidosis.

Case presentation

• After initial admission immediate transfer to the intensive care unit
• Diagnosis of an abscess in the rectogenital region however without initial surgical intervention, immediate start of protocol-based sepsis therapy
• Long-term medication of the patient: candesartan, simvastatin, hydrochlorothiazid, metformin, insulin
• Further deterioration on the intensive care unit, on the following day requirement of intubation and controlled ventilation due to increasing respiratory insufficiency
• Development of multiple organ failure and severe ketoacidosis in the context of her septic disease pattern
• Surgical focus treatment on the day after initial admission - radical skin and subcutis debridement and excision as well as significant removal of necrotic tissue
• Intraoperative diagnosis: perianal/gluteal/to retroperitoneal abscess formation in the sense of a Fournier gangrene
• Postoperative transfer to ICU with further deterioration of her circulatory (norepinephrine 1 mg/h) and metabolic status (lactate 2.9 mmol/l, pH 6.9)
• Highly elevated inflammation parameters (leukocytes 52.000, CRP 24 mg/dl, PCT 3 ng/ml) and greatly impaired renal function (creatinine 2.1 mg/dl, urea 67 mg/dl, GFR 26 ml/min, anuria)
• Antibiotic therapy initially with ampicillin/sulbactam and later metronidazol, 2 days later escalated to meronem, gentamycin, metronidazol
• Due to her acute renal insufficiency as well as the hemodynamic instability and the increased inflammation markers the decision was made to initiate CytoSorb as adjunctive therapy together with a CVVHD

Treatment

• Two consecutive treatments with CytoSorb for 24 hours each
• CytoSorb was used in conjunction with CRRT (Multifiltrate, Fresenius Medical Care) performed in CVVHD mode
• Blood flow rate: 180 ml/min
• Anticoagulation: citrate
• CytoSorb adsorber position: pre-hemofilter
Measurements
- Demand for catecholamines
- Renal function (creatinine, urea, GFR, excretion)
- Inflammatory parameters (CRP, PCT, leucocytes)
- Metabolic variables: lactate, pH

Results
- Hemodynamic stabilization with a significant reduction in catecholamine doses - norepinephrine from initially 1 mg/h to 0.5 mg/h within the first 24 hours, after 48 hours to 0.25 mg/h, patient was free from catecholamines 6 days after completion of the last CytoSorb treatment
- Moderate reduction in inflammatory parameters under CytoSorb therapy (CRP 20 mg/l, leucocytes 30,000/µl, PCT 2.5 ng/ml)
- Clear improvement in renal function during the two treatment cycles: normalization of creatine and urea values, GFR from 26 to 90 ml/min, recovery of quantitative excretion (1.6 l/24 h)
- Significant improvement of ketoacidosis, lactate decreased to 1.7 mmol/l, normalization of pH

Patient Follow-Up
- Daily surgical wound care, disinfection, removal of necrotic tissue
- Termination of renal replacement therapy 1 day after CytoSorb application with complete recovery of kidney function
- Weaning and extubation successful 6 days after CytoSorb application
- In the days post extubation, the patient presented as clinically stable
- Development of delirium, which normalized within the next 2 weeks
- Surgical installation of a sigmoidostoma and a sliding flap
- 26 days after the use of CytoSorb the patient was discharged to the normal ward

CONCLUSIONS
- Treatment with CytoSorb was accompanied by an unexpectedly rapid and significant stabilization in vital functions (renal function, hemodynamics) as well as declining catecholamine doses within the two treatment cycles
- The installation of the absorber into the CVVH circuit as well as the application of CytoSorb itself was simple and safe
Effect of extracorporeal cytokine removal on vascular barrier function in a septic shock patient.

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1 Department of Medicine, Division of Nephrology & Hypertension, Hannover Medical School, Hannover, Germany.
2 Institute of Transplant Immunology, IFB-Tx, Hannover Medical School, Hannover, Germany.

This case study reports on a 32-year-old female patient with a 4-day history of fever, malaise, and cough who was found unconscious and hypoxic by the emergency team.

Case presentation
- The patient was successfully resuscitated and after initial treatment at a local hospital transferred to the authors institution for extracorporeal membrane oxygenation (ECMO) due to influenza pneumonia, which caused respiratory failure and severe ARDS
- She also had an abscess of her left breast that grew Escherichia coli bacteria
- Due to sepsis (peak CRP 222 mg/L; peak procalcitonin 81.2 μg/L) and accompanying acute kidney injury (AKI), the patient required additional organ support by continuous veno-venous hemodialysis (CVVHD)
- Sequential Organ Failure Assessment (SOFA) score was 18
- The patient remained in refractory hypotension despite a broad anti-infective regimen, adequate fluid resuscitation, and high doses of inotropes and catecholamines
- The severity of septic shock suggested an immense overwhelming host response assumingly accompanied by a notable cytokine storm such as that known from patients with toxic shock syndrome
- Therefore, a CytoSorb adsorber was additionally installed into the CVVH circuit

Treatment
- One treatment with CytoSorb for a total of 24 hours
- CytoSorb was used in conjunction with CRRT performed in CVVHD mode

Measurements
- Demand for catecholamines and hemodynamics
- Cytokine, chemokine, and growth factor concentrations in serum (IL-1α, IL-6, IL-8, IL-9, IL-10, IL-13, FGF, GM-CSF, CXCL10 (IP-10), CCL2 (MCP-1), CCL4 (MIP-1β), PDGF-bb, RANTES, TNF-α, VEGF)
- Creatinine, lactate
- Removal of antibiotics
- Stimulation of endothelial cells with plasma from healthy control and the septic shock patient (pre- and post CytoSorb therapy)
- Transendothelial electrical resistance measurements to objectively quantify the functional permeability consequences of intercellular gaps
Results

- Improved hemodynamic stability within the process of cytokine removal - after 24 h of treatment, the mean arterial pressure (MAP) could be maintained above 65 mmHg with markedly reduced need for vasopressors, even allowing the removal of excessive fluids by ultrafiltration.
- Noradrenalin doses could be reduced from 0.40 to 0.09 μg/kg/min after the 24 hour treatment (reduction to 0.11 μg/kg/min even within the first 12 hours).
- During the course of the single treatment creatinine could be lowered from 242 to 70 μmol/L and lactate from 3.1 to 0.9 mmol/L.
- Significant removal of all cytokines and chemokines (except IL-13).
- Pre- and post-CytoSorb drug levels of antibiotics yielded a marked reduction for meropenem and piperacillin and as well as a slight reduction for clindamycin.
- Treatment of endothelial cells challenged with serum from the septic patient pre CytoSorb treatment exhibited structural alterations with an increase in permeability, the cellular correlate for the clinical “vascular leakage syndrome”, while cells stimulated with serum from the same patient after CytoSorb treatment were comparable with cells from a healthy controls (in other words, the integrity of cell junctions was better preserved after CytoSorb).

Patient Follow-Up

- Unfortunately, clinical and radiologic signs of severe hypoxic brain injury forced the authors to switch the therapeutic strategy to comfort care and the patient died the next day.

fluid showed no malignant cells.

CONCLUSIONS

- Extracorporeal cytokine removal using CytoSorb led to a stabilization of septic shock within hours.
- Due to the observed removal of antibiotics, the authors recommend thorough therapeutic drug monitoring in septic patients, as with the use of any other extracorporeal removal strategies.
- This is the first publication showing that a positive effect of CytoSorb on capillary integrity, and as a result, on microcirculation, can be assumed with a high probability.
- There is no doubt that this report from a single patient is hypothesis generating in nature, so that a future systematic study is highly desirable.
Use of CytoSorb in Streptococcus pneumoniae Sepsis

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This case study reports on a 70-year-old male patient who was admitted to hospital with acute respiratory failure. Patient’s previous medical history included coronary artery disease with a history of coronary artery bypass graft surgery (CABG), atrial fibrillation, heart failure, type II diabetes, obesity, chronic obstructive pulmonary disease, liver cirrhosis and methicillin-resistant staphylococcus aureus (MRSA) colonisation.

Case presentation
- Initially the patient’s blood pressure was 102/67 mmHg, heart rate 141/min, body temperature 38.6°C, respiratory rate 25-30/min, oxygen saturation 94% with 1.5l/min oxygen flow
- Slightly elevated inflammatory parameters (CRP 28mg/l, leukocytes 10.1 E9/l, PCT 34.5 ng/ml), moderate to severe loss of kidney function (creatinine 181 µmol/l, GFR 32ml/min/m2)
- Hemoglobin 110 g/l, thrombocytes 112 E9/l
- Compensated metabolic acidosis: pH 7.43, lactate 4.5 mmol/l, base excess -6.9 mmol/l, PaCO2 3.33 kPa, PaO2 12.6 kPa with 4l/min oxygen flow
- Chest radiograph exhibited a tight consolidation of right upper lobe due to pneumonia
- Patient was transferred to the Critical Care Unit with diagnosis of pneumonia and acute heart failure
- Treatment with bi-level positive airway pressure (BIPAP), cefuroxime and prednisolone
- Patient’s hemodynamic situation rapidly deteriorated so that both norepinephrine and dobutamine were started at maximum rates
- Rapid transfer to ICU with diagnosis of severe septic shock
- Change of antibiotics to ceftriaxone and levofloxacin
- Due to acute hemodynamic instability and his state of severe septic shock the decision was made to initiate CytoSorb as an adjunctive therapy together with a CVVHD

Treatment
- One treatment with CytoSorb for 24 hours
- CytoSorb was used in conjunction with CRRT (Multifiltrate, Fresenius Medical Care) performed in CVVHD mode
- Blood flow rate: 150 ml/min
- Anticoagulation: citrate
- CytoSorb adsorber position: pre-hemofilter
Measurements

- Demand for catecholamines
- Inflammatory parameters (CRP, PCT, leukocytes)
- Metabolic variables (lactate, base excess, pH)
- Renal function (creatinine, GFR, urinary excretion)
- Oxygenation and ventilation (PaO₂, PaCO₂, SaO₂)

Results

- Hemodynamic stabilization with a significant reduction in catecholamine doses – norepinephrine from 0.28 to 0.10 µg/kg/min and dobutamine from 3.7 to 1.2 µg/kg/min within the first 24 hours. Patient was free from catecholamines 11 hours after completing CytoSorb treatment
- Clear reduction in inflammatory parameters (CRP from 232.4 mg/l to 19.0 mg/l, leukocytes from 10.1 E9/l to 5.8E9/l)
- Lactate and base excess decreased to normal levels
- Slight improvement in renal function (creatinine 140 µmol/l, GFR of 44 ml/min/m²)

Patient Follow-Up

- Patient stayed in the ICU for a total of 2 days, followed by a period of 4 days in a normal medical ward.
- Finally, the patient was transferred to a health center for follow-up

CONCLUSIONS

- A rapid start of ICU treatment with the combination of appropriate antibiotics, CytoSorb and CVVHD stabilized patient’s sepsis associated hemodynamic instability effectively
- The installation of the Cytosorb absorber into the CVVHD circuit was simple and safe
Use of CytoSorb in hemophagocytic lymphohistiocytosis (HLH)

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This case study reports on a 49-year-old male patient who was admitted to the hospital with signs of sepsis (high lactate, hypotension, leucopenia, high LDH and ferritin) after he had undergone hematological examination 2 weeks earlier due to repeated episodes of fever of unclear origin and without final diagnosis.

Case presentation
- Transfer to the intensive care unit and initiation of antibiotic therapy with piperacillin/tazobactam
- Despite of extensive diagnostics, no focus could be identified
- Quick stabilization of the patient and transfer to Intermediate Care
- Readmission to ICU due to a marked coagulation deficiency, suggesting a disseminated intravascular coagulopathy, however ferritin plasma concentrations were significantly increased (81,393 ng/ml), which ultimately resulted in the suspected diagnosis of hemophagocytic lymphohistiocytosis (HLH-acquired form), escalation of antibiotic therapy to meropenem
- Initiation of immunosuppressive therapy with cortisone and immunoglobulins i.v. as well as chemotherapy with etoposide
- Due to persistent leucocytopenia and repeated fever, antibiotic therapy with meropenem was supplemented with vancomycin and voriconazole (without microbiological findings)
- The patient was catecholamine-free at all times and hemodynamically stable with volume resuscitation
- No improvement of the coagulation situation (fibrinogen 0.67 g/l, Quick 41%) even with substitution of fibrinogen concentrate (2x4g/day), persistent leucocytopenia and thrombocytopenia
- Patient also showed markedly increased values of inflammatory mediators (IL-6> 700 pg/ml, sIL-2R 16,000 U/ml, CRP 114 mg/l) as well as an increase in lactate dehydrogenase up to 2,000 U/l
- With the rationale of intervening with the cytokine storm and the anticipation of stabilizing the coagulopathy, decision was made to initiate CytoSorb as an adjunctive therapy together with CVVHD (without the indication for acute renal failure)

Treatment
- Eleven consecutive treatments with CytoSorb (first two treatments for 12 hours each, treatment 3-11 for 24 hours each)
- CytoSorb was used in conjunction with CRRT (Multifiltrate, Fresenius Medical Care) performed in CVVHD mode
- Blood flow rate: 150 ml/min
- Anticoagulation: citrate
- CytoSorb adsorber position: pre-hemofilter
Measurements

- Inflammatory parameters (CRP, leucocytes, IL-6, sIL-2R)
- Hematologic parameters (ferritin, fibrinogen, Quick, LDH)
- Renal function (creatinine)

Results

- Significant improvement in coagulation (fibrinogen, Quick) during the course of treatments
- Clear reduction in inflammatory parameters under CytoSorb therapy (CRP, IL-6)
- Improvement in HLH-relevant parameters (LDH and ferritin)
- No acute effect on leukocytes and sIL-2R

Patient Follow-Up

- In the further course of treatment no microbiological source could be found
- Further improvements in coagulation and slow normalization of the leukocyte count
- Transfer of the patient to Intermediate Care, later to a normal ward and discharge to the home environment
- Outpatient care under continued immunosuppressive therapy with cyclosporin, cyclophosphamide and dexamethasone

CONCLUSIONS

- The patient presented here was treated in a polypragmatic fashion due to his exceptional disease pattern and although a causal link is difficult to prove, CytoSorb treatment was associated with a gradual stabilization in his coagulation as well as a containment of the cytokine storm
- The installation of the absorber into the CVVH circuit as well as the application of CytoSorb itself was simple and safe
Use of CytoSorb in combined interventions on aorta arch and coronary arteries

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This case study reports on a 62-year old male who was admitted to Tver Regional Hospital Cardiosurgery Unit for elective coronary bypass surgery.

Case presentation
- The patient’s medical history included an acute myocardial infarction followed by elective coronary angiography revealing the following multivessel disease: anterior interventricular branch stenosis up to 75% in the proximal one-third; circumflex artery stenosis up to 90% in the medium one-third; obtuse marginal branch stenosis up to 65% in the proximal one-third; right coronary artery occlusion in the median one-third
- Elective surgical on-pump myocardial revascularization was performed and 4 distal anastomoses were created sequentially
- At the time of reperfusion, there was evidence of aorta sutures disruption and posterior aortic wall ripping accompanied by severe bleeding. Sealing did not stabilize the aortic bleedings and the decision was made to perform supra-coronary prosthetic replacement of the ascending aorta
- As on-pump times were expected to be long, CytoSorb was inserted into the cardiopulmonary bypass circuit in a preemptive manner
- The patient was postoperatively transferred to ICU where he developed an acute renal failure with glomerular filtration rate under 40 ml/min while subcompensated acidosis set in
- High doses of norepinephrine were required, cardiac index and respiration indexes dropped, initial stages of disseminated intravascular blood coagulation syndrome were noted
- At this stage it was decided to start extracorporeal renal replacement therapy with CytoSorb in the circuit

Treatment
- Four consecutive treatments with CytoSorb for a total treatment time of 120 hours (treatments for 30 hours each)
- CytoSorb was used in conjunction with CRRT (Multifiltrate, Fresenius Medical Care, Ultraflux AV1000S filter) performed in high-flux venovenous hemofiltration mode
- Blood flow rate: 150-200 ml/min (depending on the clinical situation)
- Anticoagulation: heparin
- CytoSorb adsorber in CVVH circuit position: pre-hemofilter

Measurements
- Demand for catecholamines
- Lactate
- Cardiac Index
- Respiration index
- Blood loss from drains
Results

Perioperative use:
- CytoSorb added patient safety to the predicted long 2nd cardiopulmonary bypass time and helped to prevent intraoperative SIRS onset (data not shown)

Postoperative use on ICU:
- Immediately after the start of CytoSorb the patient’s condition improved considerably
- Lactate levels dropped from 7.45 mmol/l after operation to 1.45 mmol/l after the 4th CytoSorb session
- Mean dose of norepinephrine could be reduced from 567 to 112 ng/kg/min while at the same time cardiac index improved from 2.1 to 2.7 l/min/m²
- Respiratory index increased from 134 to 289 during the course of the four treatments
- Drainage bleeding subsided from initially 900 ml directly after the operation to 0 ml after the last CytoSorb treatment

Patient Follow-Up
- Patient was extubated earlier than expected after respiratory index reached 250
- No development was CIP/CIM registered
- After a week on ICU, CVVH could be stopped and the patient was hemodynamically stable
- After 12 days the patient could be discharged from the ICU to the general ward and released from hospital 25 days after cardiac surgery

CONCLUSIONS
- In this case CytoSorb was used in both the perioperative and postoperative cardiosurgical setting
- Treatment with CytoSorb was accompanied by an unexpectedly rapid and significant stabilization in hemodynamics and declining catecholamine dosages within hours of its introduction
- Application of CytoSorb in the circuit of the HLM and in combination with CVVH and was safe and easy
Use of CytoSorb in a case of early recovery after cardiogenic shock and ACVB operation and ECMO therapy

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This case study reports on a 79-year-old female patient (pre-existing conditions: 3-vessel coronary heart disease, main stem stenosis LCA), who presented for elective coronary artery bypass surgery (ACVB). However, an emergency triple ACVB operation ahead of schedule became necessary due to acute angina pectoris.

Case presentation
- In the course of the anaesthetic induction the patient had to be resuscitated and an Extracorporeal Life Support System (ECLS) was installed as a veno-arterial (VA) bypass procedure in this cardio-pulmonary emergency situation
- Uneventful ACVB operation afterwards
- The patient was transferred to the intensive care unit on high-dose norepinephrine (600 μg/h) with vaECLS and high-grade low-output syndrome
- A few hours later catecholamines continued to rise to 2000 μg/h
- Metabolic derangement (lactate 5.3 mmol/l) and renal failure with oliguria (20 ml/h)
- Highly elevated leukocyte levels of 47,000/μl
- In anticipation of a post-reanimation syndrome with suspected cytokine storm, the metabolic derangement and arising renal failure, continuous renal replacement therapy in combination with CytoSorb were started 3 hours after the end of surgery

Treatment
- Nine treatments with CytoSorb for a total treatment time of 9 days (treatment for 24 hours each)
- CytoSorb was used in conjunction with CRRT (Multifiltrate, Fresenius Medical Care) performed in CVVHD mode
- Blood flow rate: 100ml/min
- Anticoagulation: citrate
- CytoSorb adsorber position: pre-hemofilter

Measurements
- Demand for catecholamines
- Renal function (excretion)
- Lactate
- Need for volume
- Inflammatory parameters (leucocytes)
Results

- Hemodynamic stabilization with significant reduction in catecholamine doses - after an initial increase in catecholamine doses under CytoSorb, norepinephrine could be completely tapered out after 18 hours.
- Pronounced stabilization of the capillary leak/volume shift: fluid balance within the first 11 hours of treatment equaled +7 liters; the following 24 hours this increased to +10 liters; another 24 hours later the balance was only +500 ml and continuous negative balance was possible from then on.
- Lactate fell to normal values (1.5 mmol/l) within 18 hours after initiation of therapy.
- Leukocyte plasma concentrations were 30,000/μl after 18 hours, twelve hours later 21,000/μl and a tendency towards further normalization, with normal values reached another 4 days later.
- There was no acute improvement in renal function and the patient remained oliguric/anuric (CytoSorb).

Patient Follow-Up

- Despite the marked improvement in the measured parameters, CytoSorb treatment was maintained for another 7 days in order to prevent re-occurrence of the inflammatory reaction in this case of a severely affected patient with persistent low output syndrome and the expectation of a persistent stimulus from the release of cytokines.
- Conversion of the ECLS from veno-arterial to veno-venous 5 days after surgery.
- Six days after the operation, the patient was tracheotomized, awake, alert, and responding adequately to stimuli.
- Decannulation of the veno-venous ECLS 7 days later.
- Development of a Critical-Illness Myopathy (CIM) and Critical Illness Polyneuropathy (CIP).

CONCLUSIONS

- Treatment with CytoSorb was accompanied by an unexpectedly rapid and significant stabilization in hemodynamics and declining catecholamine dosages within hours of its introduction.
- Clear and rapid stabilization of the volume shift. According to the medical team, such highly complex patient courses usually show a positive fluid balance throughout the seventh postoperative day.
- Considering the age and the severity of the disease of the patient, and notwithstanding the persistence of low-output syndrome, the physicians were able to support cardiac function through the rapid stabilization of the hemodynamics including control of the inflammatory reaction and the avoidance of additional cardio-depressing mechanisms (septic cardiomyopathy).
- Application of CytoSorb in combination with two other extracorporeal therapies (CVVHD, ECLS) was safe and easy.
SIRS and Sepsis

REGAIN CONTROL

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