

**Successful outcome of inhalation injury, active SARS-CoV-2 infection and concomitant pneumonia
in a patient with 27% full thickness burn: a case report**

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Abstract

Burn injuries are a major cause of morbidity and mortality. Next to the inhalation injury, total body surface area and age are strong predictors of mortality in burn victims.

The novel coronavirus disease (COVID-19) pandemic is associated with a fatality rate of around 3,5%. We present a case of burn victim with full thickness burn to face, scalp, both upper extremities (27% of total body surface area), inhalation injury and active SARS-CoV-2 infection with concomitant pneumonia.

The inhalation injury in COVID-19 positive patient was severe. A bronchoscopy revealed a diffuse erythema of the trachea and both main bronchi, the whole bronchial tree up to the distal segments was covered with carbonaceous material which could not be removed. We decided to treat the inhalation injury according to the guidelines for burns and acute respiratory distress syndrome. Accordingly, the patient did not receive any antiviral drugs or corticosteroids.

The reconstruction of a full-thickness scalp defect after burn presents a challenge in large size defects and in patients with comorbidities. Double layer Integra Dermal Regeneration Template (Integra LifeSciences, Plainsboro, New Jersey) was the reconstruction method of choice. The take of dermal template and split thickness skin graft was 100% and good scalp contour was achieved.

To our knowledge this is the first case report presenting a successful treatment outcome in a burn victim with inhalation injury, active SARS-CoV-2 infection and concomitant pneumonia with full thickness burn of 27% of total body surface area.

Key words: inhalation injury, COVID-19, active SARS-CoV-2 infection, pneumonia, scalp reconstruction

Introduction

Burn injuries are a major cause of morbidity and mortality. Around 11 million burns are assessed by health professionals worldwide every year (1). Mortality from burns is estimated to be around 1,5% (2). Inhalation injury additionally increases morbidity and probability of death. According to the data from the USA, incidence of inhalation injury in burn injury patients is up to 10,3% (3, 4). Inhalation injury is a significant independent risk factor for mortality in burns, and is associated with a 20% increase in mortality, increasing up to 60% when pneumonia is present as well (5). Next to the inhalation injury, total body surface area (TBSA) and age are also strong predictors of mortality in burn victims (6). Patients with inhalation injury are more likely to develop lung injury and pneumonia (7). The revised Baux Score provides an estimate of expected mortality and can be calculated according to patient's age, percent burn and presence of inhalation injury (8).

Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infection is associated with significant mortality rate. The novel coronavirus disease 2019 (COVID-19) pandemic is associated with a fatality rate of around 3,5% (9).

Treatment of such patients requires multidisciplinary approach which was proven successful in our burn center. We present a case of burn victim with full thickness burn injury to face, scalp, both upper extremities (TBSA 27%), inhalation injury and active SARS-CoV-2 infection with concomitant pneumonia.

Case Report

A 67-year-old male patient was rescued from a house fire by his relatives and was found awake, conscious and without any neurologic deficits (GCS 15), however severely affected and immobile (November 2020). The patient presented with signs and symptoms of inhalation injury and acute hypoxia on the site of accident. He was admitted to the regional hospital (Level 2 Trauma center)

while breathing spontaneously with additional oxygen applied through face mask. COVID-19 rapid antigen test was positive. During transportation his oxygen saturation was around 90%. Upon arrival to the hospital oedema of his face and lips developed, and he started to complain of difficulties in breathing. He was urgently intubated with small size orotracheal tube and mechanically ventilated. After primary stabilization the patient was relocated to our Level 1 Trauma center. The PCR test was taken at the regional hospital, however after arrival to our Level 1 trauma center the PCR test results were already available and the patient was treated as COVID positive. Also, if the results from PCR test were not available, he would be treated as COVID positive until proven otherwise. Furthermore, serology revealed negative antibodies for this virus. No other comorbidities were noted. Past medical history revealed surgery of emphysematous bulla of the right lung.

Immediately after admission burn injury was assessed by the plastic surgeon. The patient sustained 27% TBSA full thickness burn involving face, scalp, neck and upper extremities. He had burnt nasal hair, facial edema, swollen lips and there was some soot present on face. The decompressive escharotomies were performed on the left dorsum of the hand. The patient was bathed, scrubbed and dressings were applied to the protocol (paraffin gauze, wet gauze, dry gauze, bandage). After burn assessment he was admitted to COVID-19 Intensive Care Unit (ICU). Open tracheostomy was performed in ICU immediately after checking the status of upper airways where redness and swollen mucous membranes of the mouth, throat, and hypopharynx with plenty of smoke stains were noted. During the procedure he was hypoxic ($pO_2 = 7,6\text{kPa}$ or 57 mmHg) even though ventilated with 100% and PEEP $10\text{ cm H}_2\text{O}$. A bronchoscopy through tracheostomy was performed and diffuse erythema of the trachea and both main bronchi was noted. The whole bronchial tree up to the distal segments was covered with carbonaceous material which could not be removed (Figure 1). The chest X-ray image showed bilateral opacities with possible partial atelectasis of left lower lung lobe (Figure 2). Patient was ventilated with DuoPAP $28/15\text{ mmHg}$ (or $3,7/1,9\text{ kPa}$), breathing frequencies at 18/min and $FiO_2 1,0$. $SatO_2$ was between 90–94% and inhalation of 20 ppm of nitric oxide (NO) was introduced into the therapy. It was possible to reduce FiO_2 to 0,85 later on. Inhalation of heparin

with bronchodilators and N-acetylcysteine as well as high doses of intravenous vitamin C were administered. Patient developed severe acute respiratory distress syndrome (ARDS) and deep sedation (Richmond agitation-sedation scale; RASS-5) with concomitant myorelaxation with cisatracurium was incorporated into the therapy.

On the second day his condition worsened and he developed abdominal compartment syndrome with intraabdominal pressure of 25 cm H₂O and cessation of diuresis due to the paralytic ileus. Ogilvie syndrome developed. Abdominal decompression was urgently performed by median laparotomy and puncture of colon transversum and ileum and abdominal VAC therapy applied. After the procedure ventilatory mechanics improved, but he still needed high addition of oxygen (FiO₂ 0,75–0,85), NO (15–20 ppm) and relatively high driving pressures (14–16 mmHg or 1,9 – 2,1 kPa). Ultrasound showed thrombosis of right femoral vein; therefore, vena cava filter was applied.

On the third day after injury the first major dressing change was performed. Due to the respiratory and abdominal complications mentioned above, this was not possible earlier. When the patient was turned from side-to-side worsening of ventilatory mechanics and oxygenation was noticed because of large quantity of carbonaceous secretions which blocked tracheobronchial tree. It was resolved by consequent bronchoscopy.

In the following days, the patient underwent protective ventilation on BiPAP (high PEEP was set at 28 and lower between 15 and 18 cm H₂O), while PaCO₂ was kept between 6,5–8,4 kPa (48,8 – 63 mm Hg) and respiratory rate between 14 and 18 breaths per minute.

On the 7th day of hospitalization, we started with a gradual reduction of FiO₂ to 60% and on 10th day, we also succeeded in phasing out inhaled NO. Increased intraabdominal pressure persisted, mainly due to the increased amount of air, especially in the large intestines, which we managed to solve by conservative methods (rectal tube, enemas and multi-line prokinetic therapy).

Due to lung problems, abdominal compartment syndrome, and the need for moderate doses of vasoactive support (noradrenaline in doses 0,05–0,2 µg/kg/min), surgical procedures had to be postponed. Tangential excision of full-thickness burn areas on both upper extremities was performed and covered with split-thickness skin grafts (STSG) taken from femoral regions on the 12th day after admission. After the surgical procedures, the patient's condition began to gradually improve, so we gradually began to abolish sedation and lower the pressure as part of BiPAP ventilation and eventually transferred him to spontaneous breathing on 17th post-burn day (CPAP 10 cmH₂O / PS 0 cmH₂O).

Regarding COVID-19 status, we repeated the nasopharyngeal swab 1 week after the initial testing and then again after 2 weeks. On 22nd post-burn day the PCR test for COVID-19 was still positive, but the levels of IgA and IgG antibodies had increased sufficiently that it was considered safe to transfer the patient to the non-COVID burn ICU.

Thirty days after admission the fingers on the left and right hand were amputated at the level of proximal and distal interphalangeal joints, respectively. Necrectomy of demarcated scalp burn was performed, the external lamina of the skull was drilled and VAC applied, but satisfactory granulation tissue did not form.

The 3rd surgical procedure was performed on the 50th post-burn day. As a larger part of scalp was necrotic, the external lamina was extensively debrided (up to 7 mm in depth) with Elan 4[®] power system (Aesculap, Tuttlingen, Germany). Punctional bleeding appeared, and the defect was covered with double layer Integra Dermal Regeneration Template (Integra LifeSciences, Plainsboro, New Jersey). The upper lid contracture was released and reconstructed with full-thickness skin graft at the same time. Osteitis was diagnosed from bone samples by histological and microbiological examination. According to the isolated pathogenic bacteria (*Corynebacterium striatum*, *Enterococcus faecium* and *Pseudomonas Aeruginosa*) 6 weeks of vancomycin and piperacillin/tazobactam was suggested by the infectious disease consultant. Three weeks following Integra application, the

neovascularization of dermal template from the debrided scalp was sufficient and there was no infection of the dermal template noted. Thin silicone film was gently removed, and a split-thickness skin graft harvested from the femoral region was used for coverage. There was 100% graft take and good contouring of the defect was achieved (Figure 3).

During the hospital stay the multidisciplinary team included plastic surgeon, ICU specialist, infectious disease specialist, ophthalmologist, ENT specialist, general surgeon, cardiologist, clinical physiologist, dressing changing specialized nurse, dietitian, work therapist and physiotherapist. Before discharge all wounds were healed, and compression garments were made. Vena cava filter was removed. The patient (a physiotherapist himself) continued rehabilitation at home on his own wish. The hospital stay was 101 days. The follow-up visits were scheduled with plastic surgeon, ophthalmologist and cardiologist.

Discussion

To the best of our knowledge, this is the first described case report of complex combination of burn inhalation injury, active SARS-CoV-2 infection, concomitant pneumonia in a burn victim with 27% TBSA full thickness burn. From January 2011 to January 2021 our multidisciplinary team treated 30 patients with inhalation injury and the mortality rate was 20%. According to Osler et al (8), the revised Baux score in our case was 111 which is consistent with fatality rate of 50%. Our unpublished data showed that during the second epidemic period (September 2020 – March 2021) the mortality rate for a COVID patient in ICU at our hospital was 27,3%. At our Level 1 trauma center the burn center (including COVID and non-COVID burn ICU) is part of plastic surgery department and is distinct from trauma department.

The clinical exam, laboratory tests and chest X-ray imaging on the admission day already showed that the patient suffered a severe inhalation injury with development of severe ARDS. Because the

heteroanamnestic data showed no signs of infectious disease in the period before the burn and despite the positive test for COVID-19, we decided to treat the patient according to the guidelines for burns and ARDS (10, 11). Therefore, the patient did not receive any antiviral drugs (e.g. remdesivir) and corticosteroids. We believe that due to the critical condition of the first days after the burn, the treatment of acute respiratory failure, which occurred due to both primary and secondary ARDS, was of key importance. Treatment was according to ARDS guidelines (optimal PEEP settings, protective ventilation, muscle relaxation, treatment of elevated intra-abdominal pressure). Because the patient responded appropriately to conservative therapy, we did not need to use alternative methods of ARDS treatment (e.g. V-V ECMO). During this time, antibiotic treatment was targeted at isolated bacteria and the development of multidrug-resistant bacteria did not occur, which also contributed to the relatively short lifespan of antibiotic use. At that time, there was not many treatment protocols for severe active SARS-CoV-2 infection (remdesivir, corticosteroids) and based on the clinical picture, it was not possible to assess whether this was a case of respiratory damage due to burn damage or that lung damage due to the virus was already present. According to the anamnestic data (the patient showed no signs of respiratory infection before the injury) we did not decide to use corticosteroids mainly, which, considering the good outcome of treatment, supported our hypothesis that ARDS initially was probably mainly as a result of burn lung damage with the development of primary and later on secondary ARDS (and not because of active SARS-CoV-2 infection, although this part remains unrecognizable). We could say that the patient (e.g. genetic predisposition) responded optimally to the method of treatment and that we 'bought' enough time to allow the patient to begin to recover.

Due to the injury of the nasopharyngeal and oropharyngeal mucosa, the reintroduction of the Nutrivent probe to measure transpulmonary pressure was not advocated. Ventilation parameters were determined according to ARDS guidelines (lower PEEP was set according the 'stress index' method, upper PEEP given that V_T was not greater than 6 ml/kg of ideal body weight, and respiratory rate was set to the level that $PaCO_2$ was achieved somewhere between 6.0 and 8.5 kPa (45–63,8

mmHg). NO was introduced into the therapy at a dose of about 20 ppm because of persistent hypoxemia. Due to the development of severe ARDS and according to the guidelines from ARDS.net, the patient was deeply sedated (RASS-5) and relaxed with cisatracurium in continuous infusion, until his lung condition began to improve, and we were able to begin to reduce sedation and discontinue relaxation. Moreover, with decrease of FiO₂ and PEEP, the support from ventilator was lowered and patient was successfully weaned to spontaneous forms of supportive ventilation and later to spontaneous breathing.

Although the patient sustained a 27% TBSA full thickness burn, the surgical treatment was delayed until the patient was stabilized. Reconstruction of a full-thickness scalp defect presents a challenge especially in large size defects and patients with comorbidities. Available techniques of reconstruction are primary closure, tissue expansion, skin grafting, local flaps and free flaps (12). Due to the size of the scalp defect, there were no local flap options available. Patient was not stable for a free flap reconstruction. Double layer Integra dermal template was an excellent reconstruction method. Good scalp contour was achieved and despite osteitis the take of dermal template and STSG was 100%.

The PCR COVID test was taken 4 times during hospital stay. The test remained positive during the hospitalization. At 22nd day after admission the patient was considered COVID-19 negative. He did not show any clinical signs of SARS-CoV-2 infection, the cycle threshold value was above the set amount and there were IgA and IgG antibodies present in blood sample. We speculate that suppression of cellular immunity is the cause for long lasting positive COVID-19 PCR test results, however the patient was not contagious anymore. All healthcare professionals caring for the patient used personal protective equipment and there was no noted spread of COVID-19 infection.

To our knowledge this is the first case report presenting a successful outcome in treatment of a burn victim with inhalation injury, active SARS-CoV-2 infection and concomitant pneumonia with full

thickness burn of 27% TBSA. We encourage the share of experience and updated treatment protocols for burn victims in COVID-19 pandemic (13).

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Figure Legends

Figure 1. Bronchoscopy

A bronchoscopy through tracheostomy was performed on the admission day and diffuse erythema of the trachea and both main bronchi was noted. The whole bronchial tree up to the distal segments was covered with carbonaceous material which could not be removed.

Figure 2. Chest X-ray

Bilateral opacities with possible partial atelectasis of left lower lung lobe were noted on chest X-ray on the admission day.

Figure 3. Scalp reconstruction

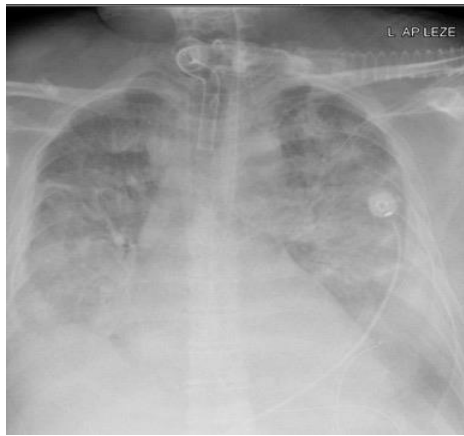
Scalp reconstruction with double layer Integra Dermal Regeneration Template (Integra LifeSciences, Plainsboro, New Jersey). Good scalp contour was achieved and although osteitis was diagnosed the take of Integra dermal template and split-thickness skin graft was 100%.

Figure 1



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Figure 2



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Figure 3



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