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# ***Conservative surgical management of necrotic tissues following meningococcal sepsis: case report of a child treated with hyperbaric oxygen.***

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## **Abstract**

This article presents the case of a 5-month-old infant, who survived a fulminant meningococcal sepsis with purpura fulminans, septic shock and severe DIC with gastrointestinal bleeding. Amputation and reconstructive surgery were considered to treat the multiple skin and limb necroses at high risk of superinfection, but the surgical intervention was delayed due to the extremely doubtful outcome. On Day 10 after the onset of the disease, a hemodynamic improvement was achieved. The baby overcame early critical period, but was still in poor general condition. The hyperbaric oxygenation (HBO2) as adjuvant therapy was started in the monoplace chamber using the following protocol: from first through fifth day 45 minutes twice a day on 1.5 atmosphere absolute (ATA); after a two-day break, once a day on 1.8 ATA for 60 minutes. During 52 HBO2 treatments multiple areas of necrotic skin and subcutaneous tissue, together with fingertips and toes, detached spontaneously. All wounds healed without reinfections. An increased oxygen concentration during HBO2 therapy promoted spontaneous wound healing. Bacterial superinfection was not observed in numerous low-perfused lesions. Since repeated anesthesia and surgical interventions were not needed, a final invalidity was minimized. To the best of our knowledge, this is the first report on the successful conservative surgical treatment of this mutilating disease without aggressive reconstructive surgery in an infant with the help of HBO2.

Key words: Ischemia; Necrosis; Oxygenation, Hyperbaric; Infections, Meningococcal sepsis

## **Introduction**

Meningococcal sepsis is the most devastating form of sepsis in children. It arises from development of endovascular inflammation, disseminated intravascular coagulation (DIC) with microvascular thrombosis, endothelial damage, toxemia and shock caused by extensive capillary leakage and bleeding into tissues and skin (1). Its manifestations range from progressive purpuric lesions of the skin, to severe soft tissue and bone damage. In the acute phase, the severity of clinical deterioration often mandates conservative intensive therapy.

Whether the skin or peripheral limb necroses are extensive, an aggressive surgical treatment or amputation may be necessary. This difficult, but life saving decision often leads to the additional mutilation of the patient (2, 3).

Hyperbaric oxygen therapy (HBOT) is characterized with breathing of pure oxygen at pressures over 1 ATA, usually from 1.4 up to the 3 ATA. It increases the partial pressure of oxygen in all the tissues of body. Under physiologic conditions an amount of oxygen physically dissolved in plasma is 0.3 ml dl<sup>-1</sup>. At

the pressure of 1.5 ATA it reaches 3.33 ml dl<sup>-1</sup> and at 1.8 ATA to 3.96 ml dl<sup>-1</sup> of blood (4).

Hyperbaric oxygen (HBO) improves microcirculation and has favorable effects as adjuvant therapy in meningococcal sepsis (1,4,5,6). HBOT can increase wound oxygen tension well above the physiologic range by increasing an amount of dissolved oxygen, regardless of the hematocrit, particularly in the wounds where microcirculation is damaged, and diffusion distance markedly increased due to the edema. It enhances wound healing by stimulating neoangiogenesis and collagen formation (6, 7, 8). HBO exerts synergistic effect when used in the combination with antibiotic therapy and suppresses super infection by increasing the polymorphonuclear leukocytes' killing ability (5).

Several preclinical studies and case reports demonstrated the positive influence of HBOT both in the early and in the late phase of the meningococcal sepsis. In this case report we present a successful delayed conservative management of this severe disease with HBOT.

### Case report

A five months old boy, weighting 7 kg was admitted to the pediatric intensive care unit (ICU) with skin temperature 40°C due to the septic shock with multiple organ dysfunction and gastrointestinal bleeding. The livid skin changes and progressive purpuric lesions were typical signs of fulminant meningococcal sepsis with severe disseminated intravascular coagulation (DIC). The blood cultures confirmed *Neisseria Meningitidis* Y/W135 infection. A complete blood count taken on the day 1 revealed a white blood cell count of 4.0 cells  $\mu\text{L}^{-1}$  with a left shift, red blood cells (RBC) were 2,700  $\text{ml}^{-1}$ , haemoglobin 74 g  $\text{dL}^{-1}$  and platelet count was 11,000 cells/mL. C-reactive protein was

208 mg  $\text{L}^{-1}$ , LDH 1155 U/L, glucose 1.8, and urea 13  $\text{mmol L}^{-1}$ . Coagulation panel revealed DIC with prothrombin time 0.25 (2.24 INR), antithrombin III (ATIII) 56%, fibrinogen 2.2 and D-dimmer 2026.



Fig. 1. Skin manifestations of the meningococcal sepsis on day 3 after hospital admission.

A fluid resuscitation, dopamine and dobutamine support with antibiotics penicillin, ceftriaxone, and high doses of steroids were immediately started in a pediatric ICU. RBC and platelet concentrate, fresh frozen plasma, human albumin and ATIII were also given. Despite administration of blood component transfusion, gastrointestinal bleeding persisted. Recombinant activated factor VII (rFVIIa, NovoSeven®) at one high dose of 6 mg was given and bleeding stopped. Anticoagulants were started thereafter.

Diuresis was stimulated with furosemide and oxygenation was provided using a face mask or oxygen tent. On day 3 the infant developed perfusion impairment with diffuse, extensive and deep skin lesions (Fig. 1). Due to the Methicillin Resistant *Staphylococcus* (MRSE) superinfection vancomycin was started on day 7. A consultant surgeon delayed surgical treatment due to the child's age and doubtful outcome, until spontaneous demarcation was achieved.

On the day 10 of the disease the infant was, for the first time, presented to our HBO unit. He needed no vasopressor therapy, but was still in poor general condition, i.e. he was edematous with minimal pericardial effusion (4 mm), adynamic, sleepy and irritable. RBC and WBC were normal, platelet count was  $703,000 \text{ cells mL}^{-1}$ , and CRP was  $9.7 \text{ mg L}^{-1}$ . Both hands and feet were gangrenous with undefined lines of ischemia, whereas fingers and toes were necrotic. Large necrotic skin areas required major surgical interventions too (Fig. 2 A, B, C).



Fig. 2. Clinical presentation on the 10th day after the onset of fulminant meningococcal sepsis. Necrotic skin areas on the left hand (Fig 2A), right hand (Fig 2B.) and toes on both legs (Fig. 2C). Hyperbaric oxygenation was started as adjuvant therapy.

HBO as adjuvant therapy was started. All wounds were dressed with moist gauzes with

normal saline only. The sessions began one hour after feeding. Phenobarbital 5 mg was given twice daily. To avoid otologic complication, the infant was given a pacifier to suck.

The treatment was carried out in the HBO mono-place chamber unit HYOX-CHU at the Department of Anesthesiology and ICU. The chamber was pressurized with 100% oxygen. During the first three days a doctor (I.T.) was with the infant in the chamber. The treatment protocol was from the 1<sup>st</sup> –to 5<sup>th</sup> day 45 minutes isopression phase twice a day on 1.5 atmosphere absolute (ATA) (4). Both compression and decompression phase were 10 minutes. After a 2 day break, the 60 minutes sessions were continued once a day on 1.8 ATA (4). In the following period of therapy the infant was alone in the chamber (Fig. 3.). He never cried, tolerated the procedure well, and was seen to smile and coo again. He did not appear to suffer any pain.



Fig. 3. On the day 7 of the HBO treatment a child was alone in the chamber at the pressure of 1.8 ATA.

After 15 treatments, the infant's physical condition improved, microbiological cultures were negative, superinfection was suppressed, and antibiotic therapy was stopped. After 25 HBO treatments necrotic

areas were dry, delineated and most of them detached spontaneously. At that time he smiled for the first time during the course of his illness. A total of 52 treatments were carried out until all wounds healed without reinfection, and without surgical intervention (Fig. 4). At discharge, the infant was in good general condition, and had a satisfactory local status.



Fig. 4. After 52 HBO sessions a complete demarcation of deep skin necrotic areas was achieved. All wounds healed without skin grafting or reconstructive surgery. Certain inevitable invalidity remains, but satisfactory function of left hand is obvious.

On the control visit one year after the hospitalization the baby was playful, walked alone in normal shoes, had no hearing or visual impairment and he had no seizures. Parents were sent to orthopedist to choose appropriate shoes.

### Discussion

Meningococcal-induced purpura fulminans is the most devastating form of sepsis in children. With improved critical care, surgical management is required in 10 to 20% of patients. The procedures commonly performed in this cohort were debridement, autologous skin grafting and allografts in 90% of patients (1-3). Although the current strategy is to delay amputations and manage wounds with the goal of preserving as much

tissue and function as possible, local flaps and amputations to viable tissue were performed in more than 40% of children undergoing surgery (1, 3, 7).

In this case report we presented a therapy of a five month old child who was a candidate for limb amputations and reconstructive surgery with skin grafting. A conservative treatment option using HBOT with pressure adjusted to the therapy of a high risk patient was chosen.

Mono-place HBO chamber is an ideal setting for HBO in children because they can breathe from the chamber atmosphere rather than via a face mask. Since we had no experiences with such a young child, we created a treatment protocol according to the available literature (4). The doctor was in the chamber at the very beginning of the treatment series, palpating pulse rate manually and keeping physical contact with the infant.

A usual course of HBO treatment lasts 8 to 10 days. As a rule one session per day is adequate for most patients. In the case of extensive wounds and severe circulatory disorders, the number of treatments per day is up to three during the first few days. Despite several reports on the beneficial effects of early adjunctive HBO treatment in ICU patients with severe soft tissue lesions (5,7), due to the organ and circulation impairment we were able to carry out only late HBOT in this case. Twice a day regime was chosen for the start of therapy and continued once a day until all wounds healed (4). HBOT helped in our efforts to minimize tissue defects since no surgical intervention was needed at that stage of disease.

In this case HBO was intended to increase oxygen concentration and diffusion gradient between blood and tissue, and to improve oxygenation in the low perfused areas (6). Although the first report on the improvement of purpura fulminans in children after HBO



treatment was published in 1965 (9), HBO is still being used rather sporadically. A lack of high-quality studies on the effects of HBO during the management of this rare and mutilating disease should not discourage this treatment (10). In clinical situations where early therapy is not possible, HBO may have important effects on wound healing even in the late phase of the disease, as presented in our patient. A final invalidity may be minimized and reconstructive surgical procedures avoided.

In conclusion, we argue for less invasive and delayed surgical treatment that may be achieved by improved interdisciplinary communication and patient-adjusted HBO therapy. Long term follow up should help in the evaluation of the effects of HBO on the functional outcome.

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