

Evaluating the effectiveness of hyperbaric oxygenation in complex of the common therapy of neonates classified as being at high risk for the development of cerebral palsy

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Abstract. The risk of obstetric and perinatal pathology development has been increased considerably in women after Caesarean section (CS). This is caused by the fact that abdominal delivery itself is accompanied by additional risk of perinatal complications for the fetus and newborn. Besides often we can see different extragenital pathologies or obstetric complications being indications for surgery. Such factors as surgical stress, anesthetic technique, and in particular, the use of analgesics, relaxants, antipsychotics influence the birth outcomes in infants born by Caesarean section because all medical treatments are able to pass through placenta and affect the fetus to a greater or lesser extent. In all these conditions both pregnant women with extragenital diseases, preeclampsia and women during the labor develop an oxygen insufficiency of maternal organism and fetoplacental insufficiency (FPI) and, as a consequence, reduced oxygen delivery to the fetus, hypoxia and fetal malnutrition. Cerebral ischemia, known as hypoxic-ischemic encephalopathy is one of the severe complications of pregnancy and childbirth, which is caused by neonatal anoxia of the brain. The most dangerous outcome of this disease in infants is cerebral palsy (CP) and epilepsy. Therefore, all therapeutic measures should be aimed at the early ensuring of fetus by an adequate amount of oxygen in order to minimize hypoxic violations of the brain [1, 2, 3, 4]. This is the method of hyperbaric oxygenation (HBO) that meets the above-noted requirements, which is pathogenic remedy for cerebral hypoxia and various forms of general hypoxia.

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Introduction

Thus the main strategy of therapeutic measures is that they are conducted in the phase of reversible disorders in order to prevent the development of gross neurological disorders in residual period [5, 6, 7, 8].

The organizational principle of the "early intervention" program is that HBO is recommended to be used not only after the birth of a child, as it was used previously, but also during the Caesarean section. HBO can also be used before labor – in antenatal period in pregnant women in cases of high risk of obstetric and perinatal pathology (in an air-oxygen hyperbaric chamber) [9, 10].

Therefore, one should carry out HBO method in conjunction with conventional therapy for the better antenatal protection of the fetus, as well as prevention and rehabilitation of obstetric and perinatal complications in all pregnant women with high risk factors during the preparation for the planned Caesarean section.

The overall strategy of rehabilitation system was developed on the basis of a database of long-term scientific and practical experience of the Republican Center of HBO (Shymkent, HBO center), the Department of Newborn Pathology and Department of Neurology in the Regional Children's Hospital of South Kazakhstan region affiliated by the specialized rehabilitation center for children of Shymkent.

The method of application of HBO method with prophylactic and therapeutic purpose included 6-10 sessions for women in term of 28 weeks, and in earlier terms if necessary. HBO is applied in women with increased risk of obstetric and perinatal pathology in an air-oxygen hyperbaric chamber, with individual modes of compression, decompression and exposure from 1.2 to 1.8 atm with the duration of the session from 40 to 60 minutes.

All patients received the combined therapy in the hospital, which included dehydration (magnesium sulfate 25%, diakarb), resolving (aloe, hyaluronidase) neurometabolics (actovegin,

encephabol), vitamin B, vasoactive drugs (Ginkgo Bilobae foliorum extract, instenon, cavinton, cinnarizinum), and physiotherapy.

In order to prevent the oxygen toxicity, it's recommended to have additional daily intake of antioxidants during HBO sessions, such as intramuscular injections of 0.5-1.0 ml of vitamin E 10% solution; subcutaneous injections of B-group vitamins (B₁, B₆); oral intake of multivitamins (vitamins A, K, PP and others, as well as trace elements); intravenous injection of 5% ascorbic acid and 2-5 ml of unithiol in glucose 5% solution or in sodium chloride 0.9% solution taking into account toxic effect of the oxygen.

Based on the literature data and results of our research, we believe that indications for HBO therapy are puerperants after Caesarean section for the treatment and prevention of obstetric complications, as well as all extracted infants with moderate and severe cerebral ischemia (with an Apgar score less than 5-6), hemolytic disease of newborn, anemia, syndrome of motor disorders, and premature babies who are indicated to undergo barotherapy sessions from 4 to 6 times at the pressure of 1.2-1.6 at (0.2-0.6 atm) with a duration of 40 to 60 min taking into account contraindications.

All infants extracted by Caesarean section should be classified as being at high risk of cerebral ischemia with further prophylactic medical examination and traditional rehabilitation in terms of outpatient department.

Materials and methods

We have carried out an assess of therapeutic and prophylactic efficacy of hyperbaric oxygenation (HBO) by monitoring the dynamics of the clinical status, the results of clinical analyzes and some biochemical parameters of blood in 105 newborns delivered by the Caesarean section in conditions of HBO, which constituted the main group (MG), while the comparison group (CG) consisted of 116 newborns extracted by an abdominal delivery under normal atmospheric conditions.

Monitoring of HBO activity was performed on the basis of analysis of fetus and a newborn using an Apgar score immediately after their extracting from the womb and in the early neonatal period according to the results of clinical and laboratory parameters. We've performed such biochemical blood tests as determination of the total protein and C-reactive protein, albumin, globulin, extracellular hemoglobin, urea, bilirubin, creatinine, total lipids by conventional methods.

Using blood gas analyzer ABC-1 manufactured by Radiometer (Denmark) and OR-215 manufactured by Radelkis (Budapest), the following

parameters of acid-base balance were determined: partial pressure of carbon dioxide in the blood (pCO₂). Partial pressure of the oxygen (pO₂) was determined using transcutaneous oxyhemograph SCI-2-20 "Radiometer" (Denmark).

Results of the study

Comparative analysis of the data obtained from the assessment of the newborns immediately after delivery and in the early neonatal period indicates more favorable results in the group of newborns (MG) delivered in the hyperbaric chamber and treated by HBO sessions, as compared with those parameters of the comparison group of children (CG). In babies born under HBO such parameters as Apgar score, weight and growth were considerably higher in comparison with the similar parameters of newborns of CG. Less pronounced metabolic changes were also revealed [pH, acid-base balance, pO₂, pCO₂, extracellular hemoglobin, proteins, urea] in infants born under HBO compared with those parameters of infants from the comparison group.

Analysis of the status of newborns assessed by Apgar score in the first minute of life showed a considerably lower rate of asphyxiated newborns delivered in hyperbaric chamber as compared to the same parameters in children from the comparison group (Table 1). Thus, in the study group and the comparison group babies were born without asphyxia in 44.3% and 21.0%, respectively, with an Apgar score of 7.0-10.0, whereas in 55.7% and 79.0% of cases they were extracted with varying degrees of asphyxia. After primary care at follow-up assessment in 5 minutes the state of newborns was regarded as "almost normal", i.e. Apgar score of 7.0-10.0 in 68.6% of children from the main group, and 32.9% of children in the comparison group. In 31.4% and 67.1% of cases the asphyxia of varying severity was revealed in the MG and CG, respectively. In newborns with asphyxia 24.7% and 41.3% of the state was consistent with Apgar scores of 4.0-6.0. In 6.7% and 25.8% of cases an Apgar score was below 4.0 in the MG and CG, respectively.

Among newborns of the comparison group severe edema was established in 24% of cases, cephalhematoma in 18.2% of cases, and retarded epithelization of umbilical wound was observed in 61.9% of children. Peripheral blood picture was characterized by normal and hypochromic anemia and leukopenia 25.4 - 38.1% of cases.

Thus, a high percentage (67.1%) of adaptation deviations was typical for infants after abdominal delivery (ABD) characterized by considerably changes in the functioning of various life-support systems. Analysis of clinical data revealed a greater frequency of implementation

period of perinatal pathologies in newborns of the comparison group (1-3 grade (from mild to severe) hypoxic-ischemic encephalopathy, infections, etc.). In the main group first grade (mild) cerebral ischemia was diagnosed, while infectious diseases were not registered. Consequently, performing the HBO procedure helps to reduce perinatal pathology. Consequently, in the main group an increase in the frequency of birth of almost healthy newborns by 36.5% was found, while reducing in the frequency of infants with asphyxia was achieved by more than 36.5% compared with those in the comparison group ($p < 0.001$).

Table 1. Comparative assessment of infants born under HBO and in the comparison group

Apgar score (in points)	Main group		Comparison group	
	In the first minute of life, immediately after extracting from the womb (%)	5 minutes after extracting from the womb and giving the first aid (%)	In the first minute of life, immediately after extracting from the womb (%)	5 minutes after extracting from the womb and giving the first aid (%)
7.0-10.0 points (no asphyxia)	44.3	68.6	21.0	32.9
4.0-6.0 points (mild hypoxic condition)	44.2	24.7	49.8	41.3
Below 4.0 points (severe hypoxic condition)	11.5	6.7	29.2	25.8

At the same time, despite resuscitative measures and intensive treatment, four newborns from the comparison group (5.3%) died within 20-40 minutes after delivery, whereas there were no lethal cases in the main group.

In children of the main group who received HBO in combination with conventional therapy, a tendency to restore vital functions and involution of neurological disorders was established immediately after the first session of HBO. This positive tendency was observed in the form of a slight improvement in general condition, disappearance of signs of respiratory distress syndrome, revitalizing of some reflexes, disappearance of regurgitation and nystagmus.

Therapeutic effect of HBO was quite obvious during the 2nd and 3rd session when a marked improvement in patient's condition was achieved by a direct use of hyperbaric chamber during the session: children flushed, active and tentative movements appeared. Positive changes in the patient's condition were also seen in the reaction of support activation, crawling on the background of reducing in the clinical symptoms of neurological dystonia with short-term reactions of eye fixation and tracking items that were not long and continuing only 2-3 hours.

Consequently, the results of the conducted observations give reason to believe that the use of HBO method is able to correct and activate violated functions of the central nervous system (CNS) in newborns and infants suffered for perinatal reasons.

However, restoration of vital functions and involution of neurological disorders were not so long. This dictates the use of HBO in the principles of preventive regimen during reversible damage to child's CNS cells at an earlier date of ontogenesis of its development.

Efficacy of HBO method in the preoperative stage, during the Caesarean section itself and in neonates in the early neonatal period is confirmed by the stabilization parameters of acid-base status, which is an integral indicator of the overall metabolism of the body.

Consequently, the obtained findings suggest on the high efficiency of HBO aimed at normalization of metabolism, which certainly has a positive effect on the clinical status of the newborns.

Table 2. Blood gas levels in newborns of the main group (MG) and comparison group (CG)

#	Parameters	Newborn babies (in the first three days)		
		from physiological delivery (N = 25)	MG (N = 26)	CG (N = 28)
1	pH	7.30 ± 0.01	7.28 ± 0.01 *	7.06 ± 0.01 ***
2	pCO ₂	43.38 ± 2.35	42.60 ± 1.98	45.30 ± 1.86
3	BE	(-5.87 ± 0.61)	(-7.22 ± 0.65)	(-9.43 ± 0.74) ***

Note
* - $P < 0.05$, *** - $P < 0.001$ – significance of differences in parameters as compared with those of the control group.

The findings suggest about high-efficiency of HBO parameters on gas exchange within the framework of stabilization of acid and base exchange and pCO₂ in neonates after Caesarean section. This result, of course, also has a positive effect on the clinical status of this group of children.

Conclusions

Hyperbaric oxygen therapy is applied in order to prevent the development of gross neurological disorders in the fetus during the residual period. 6-10 sessions were conducted for women with high-risk of obstetric and perinatal pathology from the term of 28 weeks. HBO was carried out in the air-oxygen hyperbaric chamber with individual mode of compression and decompression and exposure from 1.2 to 1.8 atm with a session lasting 40 to 60 minutes. The efficacy of hyperbaric oxygenation was assessed by analyzing the status of fetus and newborn using Apgar score immediately after their extracting from the womb, and in the early neonatal period using the results of clinical and lab parameters. The comparison group included 116 newborns extracted without the use of HBO in normal atmospheric conditions.

A high percentage (67.1%) of adaptation deviation characterized by significant changes in functioning of various life support systems was observed in infants after abdominal delivery. Analysis of the clinical data revealed a greater

frequency of perinatal pathology in newborns from the comparison group (mild to severe hypoxic-ischemic encephalopathy, infections, etc.). Mild cerebral ischemia was diagnosed in the main group, while the infectious diseases were not registered. This confirms the high efficiency of HBO method aimed at reducing of hypoxic ischemic encephalopathy and development of cerebral palsy.

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