ANESTHESIA FOR RADICAL SURGERY OF NEONATAL CONGENITAL DIAPHRAGMATIC HERNIA USING CONTINUOUS ADMINISTRATION OF FENTANYL AND HIGH-FREQUENCY OSCILLATORY VENTILATION

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Abstract: Patients with congenital diaphragmatic hernia were managed using continuous administration of fentanyl and high-frequency oscillation during the perioperative period. Fentanyl was continuously administered at 0.076 μ g/kg/min and initial settings for high-frequency oscillation were: fraction of inspired oxygen=0.75, frequency=15 Hz, stroke volume=6.7 ml/kg, mean airway pressure=19 cmH_2O. All the patients were administered dopamine and dobutamine for hemodynamic stability. Their operations were completed with no problem.

Index Terms

CDH, fentanyl, HFO, pulmonary hypertention

Since the proposal by Miyasaka et al., patients with neonatal congenital diaphragmatic hernia (CDH) have been treated with delayed operation for the prevention of exaggerating persistent pulmonary hypertension by operative stimulus and also for improvement of respiratory and circulatory condition during a few days following the birth[1)2)3)]. We have already reported the effectiveness of preoperative management of CDH with high-frequency oscilatory (HFO) ventilation[4)]. However, there were few anesthetical reports for CDH during radical surgery controlled by HFO ventilation. We report here the successful management of four patients of severe CDH during radical operation by HFO ventilation and neuroleptic analgesia with continuous administration of fentanyl.

MATERIALS

Five patients with CDH were operated on at Nara Medical University between July, 1988 and October, 1993. Four of them were managed with HFO and one with an extra corporeal membrane oxygenator (ECMO); latter case is excluded from this report. The backgrounds of the patients are shown in Table 1.

RESULTS

Average gestational age was 39 weeks and 6 days, and average weight was 3215.8 g. All the patients showed cyanosis and dyspnea and were intubated within a few hours after birth. All

were diagnosed as having CDH by radiological examination, and admitted to NICU. They were ventilated by HFO using a Hummingbird ventilator (Senko Ika Kogyo Ltd., Tokyo, Japan), and administered dopamine (DOA) and dobutamine (DOB). Prostaglandin E_1 (PGE_1) was given in one case.

After stabilization of hemodynamic and metabolic conditions, their radical surgeries for CDH were scheduled at 2-4 days after birth. The infants were given no premedication, and anesthesia was maintained by neuroleptic analgesia (NLA) with continuous administration of fentanyl 0.076 μg/kg/min and 0.423 μg/kg/min pancuronium. ECG, body temperature (BT), pulse oximetry (SpO_2), arterial blood pressure (ABP), central venous pressure (CVP), and urinary volume were recorded. Transcutaneous PO_2 and PCO_2 were measured in one case. All the patients were managed with HFO during the operation. The average ventilator settings were: before herniorrhaphy FiO_2=0.63, f=15 Hz, SV=5.8 ml/kg, MAP=13 cmH_2O; after herniorrhaphy FiO_2=0.58, f=15 Hz, SV=5.8 ml/kg, MAP=12.5 cmH_2O; after surgery FiO_2=0.6, f=15 Hz, SV=5.7 ml/kg, MAP=12.3 cmH_2O. Blood gas analysis gave the following values: before herniorrhaphy PaO_2=191.3 mmHg, $PaCO_2$=26.4 mmHg, BE=2.8 mEq/l, pH=7.56; after herniorrhaphy PaO_2=168.8 mmHg, $PaCO_2$=32.0 mmHg, BE=1.6 mEq/l, pH=7.49; after surgery PaO_2=146.3 mmHg, $PaCO_2$=36.9 mmHg, BE=0.2 mEq/l, pH=7.43. (Table 2) After radical herniorrhaphy, the lungs were not inflated by force, and continuous drainage was instituted. All the patients were administered 4 μg/kg/min DOA and 4 μg/kg/min DOB to control hemodynamics. Systolic blood pressure (SBP) and heart rate (HR) were maintained as follows: SBP=60-65 mmHg and HR=160-185/min before surgery, SBP=55-75 mmHg and

Table 1. Backgronuds of patients

Pt. NO	1	2	3	4	Average
Gestational age (day)	285	283	256	290	278.5
Weight at birth (g)	3040	3200	3325	3298	3215.8
Apgar score (1 min.)	5	5	4	6	5
Age at operation (day)	2	2	3	4	2.8
Dopamine (μg/kg/min)	5	5	3	3	4
Dobtamine (μg/kg/min)	5	5	3	3	4
Isoproterenal (μg/kg/min)	0.01	0.02			0.015
PGE1 (μg/kg/min)	0.02	0.02			0.02
Result	alive	alive	alive	alive	

Table 2. Blood gas analysis

	Before surgery	Before Herniorrhaphy	After herniorrhaphy	After surgery
FiO_2 (%)	0.7	0.6	0.6	0.6
MAP (mmHg)	12	12.5	12.5	12.3
SV (ml)	19.3	18.8	18.8	18.3
SV/BW (ml/kg)	6	5.8	5.8	5.7
PaO_2 (mmHg)	254.3	191.3	168.8	146.3
$PaCO_2$ (mmHg)	27.0	26.4	32.0	36.9
pH	7.54	7.56	7.49	7.43
BE (mEq/l)	2.1	2.8	1.6	−0.2

HR=180-195/min before herniorrhaphy, SBP=65-80 mmHg and HR=170-180/min after herniorrhaphy. The average volume of infusion was 5.3 ml/kg/h, urination was 1.0 ml/kg/h, transfusion was 3.1 ml/kg/h, hemorrhage were 2.65 ml/kg/h. Immediately after surgery the patients were placed under intensive care in the NICU and managed with HFO for 23.8 days on average. They were extubated on average 31.5 days after surgery. All the patients were discharged from the hospital without problems.

DISCUSSION

Pulmonary hypertension associated with CDH is caused by not only pressure from the intrathoracic bowels but also pulmonary pathohistological changes such as hypoplasia of the lung, pulmonary arterial wall hypertrophy, and a decrease of pulmonary arteries associated with reduction of alveoli[5)6)]. In addition, the neonatal pulmonary artery is highly sensitive to stimuli such as excitment, acidosis, hypercapnea and hypoxia, which exacerbate the pulmonary hypertension and make the management of CDH difficult[7)]. Recently It has been advocated that total correction for CDH should be performed delayly, because reponses to invasive stimuli of surgery immediately after birth are exaggerated, and the incidence of reacive PH decreases a few days after birth[8)]. In our four successfully managed cases, delayed surgery was perfomed at 2.8 days after birth on average.

CDH patients should be managed with a consistent view from before to after surgery. First, with regard to problems of respiratory care, it was difficult to manage these patients with intermittent positive pressure ventilation (IPPV). High airway pressure is nesessary in order to maintain sufficient oxygenation with IPPV because of unequal bilateral lung's compliance. This causes some alveoli to hyperextend, leading to a high incidence of pulmonary barotrauma and elevated pulmonary vascular resistance. It is necessary to increase the frequency or tidal volume with conventional IPPV to maintain a low $PaCO_2$, but increasing the tidal volume may cause elevation of airway pressure, and increasing the frequency may cause air-trapping. On the other hand, HFO overcomes such problems and it now the main method of respiratory management in CDH. Lung compliance in patients with CDH is not equal bilaterally and in each alveolus. Hewever, the respiratory management with HFO is not affected by such differences because of the minimum pressure gradient produced by the small stroke volume and high frequency. Therefore, sufficient oxygenation can be delivered with little inequality of ventilation-perfusion. During HFO, PaO_2 can be controlled by changing the stroke volume, which is too small to affect the mean airway pressure and extend the lung excessively. Futhermore, reactive pulmonary vasospasm seldom occurs because of the small acount of stress the lung receives. For these reasons, respiratory management of CDH should be prefered HFO before, during and after surgery[9)10)11)12)].

On the basis of our experiences in these cases, we think that standard settings of $FiO_2=0.6$, f=15 Hz, MAP=15 cmH_2O should be employed, according to arterial blood gas analysis. Our recommended values are PaO_2 about 100 mmHg, $PaCO_2$ about 25 mmHg, pH over 7.4 for alkalosis. Oxygen saturation by oximetry (SpO_2) should be measured continuously, and preductal SpO_2 at the right hand and postductal SpO_2 at the foot should also be monitored. Expiratory carbon dioxide concentration during HFO could not be measured, but transcutaneous $PaCO_2$ measurement was useful.

Anesthesia should be preferred neuroleptic analgesia (NLA) with continuous administration of fentanyl to prevent pulmonary vasospasm caused by the pain of the operation and HFO and so on. Anesthesia and sedation should also be continued from the preoperative to the postperative period[13)14)]. This was supported by the fact that blood gas parameters during surgery (with anesthesia) were improved as compared with before surgery (without anesthesia) and after surgery (without anesthesia). Bolus injection of fentanyl may cause blood pressure reduction in neonates, therefore, it should be administered continuously. The patients developed bradycardia due to the fentanyl before surgery, but this did not require treatment. With regard to hemodynamic stability, although isoproterenol is the first choice of catecholamine in some institutes[9)], we used combination of dopamine and dobutamine to maintain hemodynamics and sufficient urination. As for vasodilators, although it is difficult to improve pulmonary hypertension by vasodilation because of the paucity of proliferated pulmonary vascular beds in CDH patients. Recently nitric oxide (NO) has been useful for CDH patients for reduction of pulmonary hypertension[15)]. We will also use NO with CDH patients with pulmonary hypertension.

Infusion and trasfusion were limited to a minimum volume maintaining stable urination and preventing postoperative lung edema because radical surgery for CDH included both abdominal and thoracic surgery. Body temperature should be controlled carefully by raising the room temperature, and using warmed infusion and inspired air with adequate humidification of the respiratory tract.

CONCLUSION

We have been able to successfully manage CDH patients undergoing radical surgery using NLA based on continuous administration of fentanyl and HFO for ventilation. We cosider that anesthesia and HFO play an important role before, during and after surgery.

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