References

1 Chamberlain G, Garcia J. Pregnant women at work. *Lancet* 1983;i:228-30.
2 Barlow SM, Sullivan FM. *Reproductive hazards of industrial chemicals*. London: Academic Press, 1982.
3 Hemminki K, Saloniemi I, Luoma K, *et al*. Transplacental carcinogens and mutagens: childhood cancer, malformations, and abortions as risk indicators. *J Toxicol Environ Health* 1980;**6**:1115-27.
4 Clarke M, Clayton DG. The design and interpretation of case-control studies of perinatal mortality. *Am J Epidemiol* 1981;**113**:636-45.
5 Office of Population Censuses and Surveys. *Classification of occupations*. London: HMSO, 1970.
6 Central Statistical Office. *Social trends*. No 14. London: HMSO, 1983.
7 Clarke M, Clayton DG. Quality of obstetric care provided for Asian immigrants in Leicestershire. *Br Med J* 1983;**286**:621-3.
8 Wigglesworth JS. Monitoring perinatal mortality, a pathophysiological approach. *Lancet* 1980;ii:684-6.
9 Clarke M. Perinatal audit: a tried and tested epidemiological method. *Community Med* 1982;**4**:104-7.
10 Nielsen J, Holm V, Haahr J. Prevalence of Edwards' syndrome. Clustering and seasonal variation? *Hum Genet* 1975;**26**:113-6.
11 Taylor AI. Autosomal trisomy syndromes: a detailed study of 27 cases of Edwards' syndrome and 27 cases of Patau's syndrome. *J Med Genet* 1968;**5**: 227-41.
12 Acheson ED. Nasal cancer in the Northamptonshire boot and shoe industry. *Br Med J* 1970;i:385-93.
13 Gardner MJ, Winter PD, Taylor CP, Acheson ED. *Atlas of cancer mortality*. Chichester: John Wiley and Son Ltd, 1983.

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Life support for 10 weeks with successful fetal outcome after fatal maternal brain damage

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Abstract

A 31 year old woman in whom subarachnoid and intracerebral haemorrhage occurred during the second trimester of pregnancy was sustained in intensive care with a respirator for 10 weeks. Computed tomography of the brain showed bilateral intraventricular haemorrhages. Because of drug resistant hypotonic episodes at 31 weeks' gestation caesarean section was performed, and a boy was delivered. The woman died of spontaneous cardiac arrest two days after caesarean section, and the boy showed normal development.

Life support can be continued for several weeks in a modern intensive care unit after fatal insult to the brain even in a pregnant woman without affecting the fetus.

Introduction

Improved life support with modern techniques has increased the possibility of prolonging pregnancy in mothers with acute fatal illness. Sometimes one or two weeks' life support is enough for the fetus to survive. Fatal maternal illness during the first or second trimester of pregnancy causes medical, ethical, and legal problems. There is no routine practice for obstetric or perinatal management of pregnancy in these cases. We report a case of successful life support for 10 weeks in a mother with fatal subarachnoid and intracerebral haemorrhage during the second trimester of pregnancy.

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Case history and initial neurological findings

The patient was a 31 year old woman, gravida 4, para 3. She had no history of neurological disease, and her previous pregnancies had been normal. The present pregnancy had been uncomplicated until she sustained acute severe headache and nausea at the beginning of the 21st week of gestation. After a few hours she lost consciousness, which was never recovered. In the ambulance spontaneous respiration stopped, and she was ventilated manually for about 40 minutes until it was possible to intubate her and connect her to a respirator. During transport she was hypotonic (systolic blood pressure 50-60 mm Hg) but her pulse rate was regular.

On admission to hospital her pulse rate was 100 beats/min and her blood pressure 100/60 mm Hg. She was deeply unconscious and unresponsive to pain, with flaccid tetraplegia. Her pupils were maximally dilated and pupillary reflexes were absent. On funduscopy bilateral papilloedema and retinal haemorrhage were found. Computed tomography of the brain showed bilateral intraventricular haemorrhages, a large intracerebral haemorrhage (size $52 \times 30 \times 47$ mm) in the left frontoparietal region, and bilateral small haematomas in the area of the capsula interna. The midline of the brain was displaced about 15 mm to the right. Her clinical condition was grade 5, according to the criteria of Hunt and Hess,[1] and so there were no grounds for operative treatment. She was connected to a volume controlled respirator, and dexamethasone treatment was started to decrease brain pressure.

On the second day in hospital her temperature decreased to 33°C, but it later stabilised at about 35°C. At neurological examination only the corneal reflexes could be elicited by a strong stimulus. On and after the fourth day all brain stem reflexes (pupillary, oculocephalic, oculovestibular, corneal, and swallowing) were absent. An apnoea test was not performed because of the living fetus. Her clinical condition remained unchanged. The first electroencephalogram, obtained on the second day in hospital, showed occasional slight activity in the temporobasal region; the second electroencephalogram, obtained the next day, showed slight and temporary theta activity in the frontotemporal region. On the fourth day the electroencephalogram was isoelectric. One week later there was slight activity in the right parieto-occipital area. This finding remained constant and was also registered one day after caesarean section.

Later course and management

Although the maternal prognosis was considered to be hopeless and no spontaneous breathing was present, intensive care with the

respirator was continued. This decision was made together with the woman's husband, who approved it despite the risk that the periods of maternal hypotension might have harmed the fetus. Ventilation and partial pressure of oxygen were controlled according to the results of blood gas analyses three to six times a day. During the first week she suffered from aspiration pneumonia. Blood cultures showed an infection with pseudomonas, which was successfully treated with piperacillin.

Her fluid balance and nutritional state were controlled by combined enteral and parenteral administration via a nasogastric tube and a subclavian cannula. For enteral nutrition an emulsion combination of protein, fat, carbohydrate, and vitamins was used. The basis of the parenteral substitution was solutions of 30-50% glucose and 9% amino acids. Because of a tendency towards hypotension and anaemia she received infusions of albumin and whole blood weekly. Her energy intake was 0·13-0·27 MJ (30-65 kcal)/kg/day, roughly half being given by the enteral route. Liver function and blood coagulation tests yielded normal results during the period of observation. In the second week hypotonic episodes occurred with a tendency towards hypokalaemia, indicating central adrenal insufficiency. The serum adrenocorticotrophic hormone concentration was 16 ng/l. Hydrocortisone substitution was started. Simultaneously, a hypothyroidal condition was diagnosed (serum unconjugated thyroxine concentration 45 nmol/l (3·5 μg/100 ml) and treated with thyroxine 0·05 mg. During the third week of treatment her urine volume increased massively and urine osmolality decreased to 244 mmol(mosmol)/kg. Diabetes insipidus was treated with intranasal vasopressin 0·1 ml (10 mg).

Several hypotonic episodes occurred, with systolic blood pressure falling to 70-90 mm Hg. She received dopamine as an inotropic agent if necessary (2-3 μg/kg/min). This was sufficient to raise the systolic blood pressure to 100 mm Hg. An electrocardiogram and pulse rate were normal.

Fetal wellbeing was monitored daily by recording the pulse rate and weekly by ultrasound examination. After the 28th week of gestation weekly cardiotocographic recordings were made. Biparietal measurements and fetal abdominal circumferences were normal and appropriate to gestational age. The fetus continually showed normal body and limb movements and freathing activity. Amniotic fluid volume and placental structures were normal, and cardiotocography did not yield any abnormal findings. During the 24th week the concentration of follicle stimulating hormone in the maternal serum was 5·7 U/l and of luteinising hormone more than 10 000 U/l. Correspondingly, the concentration of human placental lactogen was 3·7 mg/l and of oestriol 274 nmol/l (7·9 μg/100 ml). In repeated analyses the serum prolactin concentration was 28·0-36·0 μg/l. Analyses of amniotic fluid lecithin to sphingomyelin ratio and phosphatidyl glycerol during the 30th gestational week showed an immature fetal pulmonary condition.

At 31 weeks and one day of gestation the maternal blood pressure began to fluctuate with long hypotonic episodes and did not respond to dopamine infusion as well as it had done at previous stages of the pregnancy. Caesarean section was performed and a boy with a birth weight of 1600 g and Apgar scores of 6-7 delivered. The uterus was found to be twisted roughly 90° around its longitudinal axis at operation. The infant appeared to be well developed on examination immediately after birth, but the neonatal course was complicated by hyaline membrane disease and pneumothorax. There were no histopathological changes in the membranes or placenta.

Later the child was examined at regular intervals and showed normal development. He rolled over at 3 months after the estimated birth date, crawled at 7 months, and sat at 8 months. On examination at 8 months he was lively and babbling; all three variables of growth (weight, length, and head circumference) were between the 16th and 50th percentiles of the mean for age. Examination showed no abnormalities in his psychomotor development, and his vision and hearing were normal. Ultrasound scanning of the brain at 1 and 3 months gave normal results; similarly, an electroencephalogram showed normal brain function at birth and at 8 months.

Maternal intensive care was continued after caesarean section, but a spontaneous arrest of heart activity occurred on the second postoperative day after a drug resistant hypotonic episode. At necropsy total necrosis of the brain and cerebellum was evident. The brain tissue consisted of a liquid mass in which it was impossible to recognise intact vessels or other structures. After lavage of this material the remnants of a ruptured aneurysm in the area of the left middle cerebral artery were found. The hypophysis was highly degenerated and largely necrotic as were the brain stem and medulla of the spinal cord. Necrosis was histopathologically at the stage of resolution.

Discussion

Our patient had subarachnoid and intracerebral haemorrhages from a ruptured saccular aneurysm, which led to increased intracranial pressure and irreversible coma. After successful life support for 10 weeks the heart stopped two days after caesarean section despite continued intensive care with a respirator. From the fourth day after the primary insult she was unconscious, unresponsive, and completely dependent on the respirator. One electroencephalogram obtained soon after her admission was isoelectric, but later electroencephalograms showed very slight, unspecific intermittent activity up to the last recording, one day before cardiac arrest. Spudis *et al*[2] recorded a similar electroencephalographic pattern in a patient connected to a respirator for six months after loss of brain stem reflexes. In our patient the extensive brain damage evident at necropsy was compatible with the clinical findings showing no detectable cerebral or brain stem functions. The possibility that the activity on the last electroencephalogram was an artefact cannot be absolutely excluded. Histological examination indicated that the anatomical changes in the brain did not develop after the cardiac arrest. Necrotic tissues also occupied large areas of the spinal cord and brain stem, which are considered to be essential in cardiovascular regulation.

In previously reported cases of maternal irreversible coma treated with a respirator with successful fetal outcome the life support had not been begun before the 25th week of gestation.[3] Some comatose patients not connected to a respirator have been capable of delivering a viable infant.[4] Our case shows that in a modern intensive care unit life support can be continued for a surprisingly long period after a fatal insult to the brain without affecting the fetus. The considerable irreversible brain damage in our patient was evident not only from the severe clinical and neurological findings but also from the loss of homoeostatic regulation. Strict control of haemodynamics (hypotension), gas exchange (pneumonia and absence of spontaneous breathing), and electrolyte and nutritional balance is particularly important for both the maternal and fetal organs in such cases, and hypophysial substitution must also be carried out. Nasogastric administration of emulsion substrates was of great practical help, in addition to the intravenous route of support. The development of the fetus was normal in all respects, and fetoplacental function was also normal despite the temporary hypotonic and hypoxic periods. The birth weight was above the 50th percentile for normal pregnancy, and development after the neonatal period was completely normal. The low maternal serum prolactin concentrations, which corresponded to those in non-pregnant subjects, may have been of decidua-chorion origin.[5]

In conclusion, in some cases pregnancy can be maintained for several weeks despite fatal maternal brain damage. Modern intensive care can be carried out without affecting the fetus severely. Early diagnosis of the impairment of maternal vital functions and a rational compromise between the risks of prematurity and of continuing pregnancy are of primary importance in these cases. The pathophysiology of maternal and fetal vital functions in such cases must, however, be examined further. Pregnancy itself might have a role in maintaining maternal cardiovascular and other essential functions, even after considerable loss of function of the central nervous system.

References

1 Hunt WE, Hess RM. Surgical risk as related to time of intervention in the repair of intracranial aneurysms. *J Neurosurg* 1968;**28**:14-20.
2 Spudis EV, Penry JK, Link AS. Paradoxical contributions of EEG during protracted dying. *Arch Neurol* 1984;**41**:153-6.
3 Dillon WP, Lee RV, Tronolone MJ, Buckwald S, Foote RJ. Life support and maternal brain death during pregnancy. *JAMA* 1982;**248**:1089-91.
4 Sampson MB, Petersen LP. Posttraumatic coma during pregnancy. *Obstet Gynecol* 1979;**53**:1-2S.
5 Healy DL, Kimpron WG, Muller HK, Burger HG. The synthesis of immunoreactive prolactin by decidua-chorion. *Br J Obstet Gynaecol* 1979;**86**:307-13.

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