J Anesth (1996) 10:218–220

Journal of
Anesthesia

Clinical reports

Simple deep hypothermia for excision of a Wilms' tumor with intracardiac growth

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Key words: Wilms' tumor, Intracardiac extension, Anesthetic management, Simple deep hypothermia

Introduction

We performed a one-stage complete excision of a Wilms' tumor originating from the right kidney extending to the right atrium (RA) via the right renal vein and inferior vena cava (IVC). After nephrectomy, the patient was surface-cooled to 20°C body temperature under deep ether anesthesia. Open heart surgery was performed to excise the tumor in the RA and IVC during elective circulatory arrest for 66 min, and cardiac resuscitation was achieved. The course of anesthesia and surgery is reported along with a review of other cases concerning anesthetic control for tumor removal under extracorporeal circulation.

Case report

A 7-year-old girl, height 155.4 cm, weight 17.3 kg, was admitted to our hospital with a complaint of an abdominal mass. She had been well since birth with favorable growth and no major illness. Physical examination revealed a well-developed girl with clear consciousness and a good general condition. The diagnosis of Wilms' tumor was based on computed tomography (CT), magnetic resonance imaging (MRI), angiography, echography, and open biopsy findings. The tumor originated from the right kidney and extended to the RA via the right renal vein and IVC. The laboratory examinations were normal except for a white blood cell count of 2.3×10^9 cells·l^{-1} and a total protein of 53 g·l^{-1}.

After radiation therapy, surgery was performed under simple deep hypothermia to remove the tumor.

The patient was premedicated with diazepam (5 mg) the night before and (5 mg) again in the morning. Atropine sulfate (0.1 mg), hydroxyzine hydrochloride (10 mg), and pethidine (12.5 mg) were injected intramuscularly 60 and 30 min prior to induction of anesthesia. She was monitored by electrocardiogram (ECG), arterial blood pressure (ABP), central venous pressure (CVP), electroencephalogram (EEG), arterial blood gas analysis, rectal and esophageal temperature, and urine volume.

The patient was placed supine on the special hypothermia operating table, as shown in Fig. 1, and anesthesia was induced with thiopental (120 mg) and succinylcholine chloride (20 mg) intravenously. After inhalation of 20 ml ether (about 1 ml·kg^{-1}) from a wick-type vaporizer in the closed circuit, the patient was covered with a vinyl sheet, immersed into ice water by lowering the inner table, and at the same time the laparotomy was started. The patient inhaled 30 ml ether and was cooled to 30°C body temperature for 80 min; the cooling was stopped by raising the inner table. A right nephrectomy was completed while maintaining mild hypothermia at 30°C for about 4 h. After ward, the patient inhaled an additional 40 ml ether (3 ml·kg^{-1} in total). Recooling was instituted and a deep hypothermia of 19.8°C was achieved. Following intravenous administration of 2000 units of heparin, the aorta, pulmonary artery, and superior vena cava were clamped; 20 ml Young's solution (5 g potassium citrate, 12.3 g magnesium sulfate and 5 mg vagostigmine in 500 ml solution) was transaortically infused into the coronary artery to cause elective cardiac standstill. Tumor removal was extremely difficult because it firmly adhered to the inside of the IVC and this required 66 min of circulatory arrest. The removed kidney measured 9 × 6.5 × 3.5 cm

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Received for publication on August 28, 1995; accepted on February 7, 1996

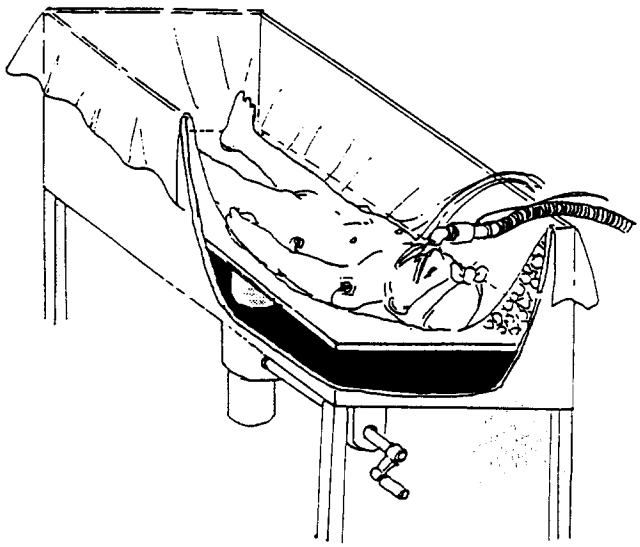

Fig. 1. Operating table for hypothermia of the type used at Iwate Medical University. An inner table, within a tank-like tub filled with water, can be raised or lowered easily. The patient, when immersed in ice water for cooling or hot water for warming the body, is covered with a vinyl sheet. The operation can be performed by raising the inner table to an operational level

and weighed 125 g. The tumor embolus in the IVC had a diameter of 1 cm and length of 9 cm. After the tumor was excised, a mixed solution of 0.5 ml 0.1% norepinephrine, 5 ml 2% $CaCl_2$ and 5 ml 20% glucose was injected into the coronary artery transaortically and cardiac resuscitation was accomplished. While the body surface was being warmed with 42°C water, 40 mg protamine was administered. The subsequent circulatory dynamics were stable and the body temperature returned from 20°C to normal smoothly within 120 min. Risky arrhythmia, such as ventricular tachycardia or extrasystole, an abnormal ST segment on the ECG, did not appear during the course of anesthesia.

The ABP decreased gradually parallel to the lowering of body temperature from 115/75 mmHg at 36°C to 45/25 mmHg at 20°C. The HR decreased gradually from 140 bpm before cooling to 30 bpm at 20°C. Both ABP and HR recovered to control levels after rewarming at 36°C. The CVP was maintained at about 10 mmHg with transfused blood and water.

The EEG showed a decrease in frequency and amplitude from 19 cps and 90 mcV after induction of ether anesthesia at 36°C to 8 cps and 25 mcV at 23°C; it then went flat at less than 23°C body temperature including during circulatory arrest. After cardiac resuscitation and rewarming, the EEG recovered to control at 36°C.

The patient's water balance was as follows during anesthesia for 12.5 h: The measured blood loss and urine volume were 4550 g and 603 ml (2.8 ml·kg^{-1}·min^{-1}), respectively. She was transfused with 150 ml of low molecular weight dextran, 1200 ml of Ringer's lactate solution, 600 ml of 5% dextrose, 320 ml of 7% $NaHCO_3$, 8 units of stored whole blood, 17 units of concentrated red blood cells, 12 units of fresh frozen plasma, and 10 units of platelets.

An artificial heart-lung machine was placed on standby, without cannulation into the great vessels, during surgery, for any unexpected occurrence, i.e., difficulty of cardiac resuscitation or prolonged circulatory arrest for over 75 min. Postoperatively, the endotracheal tube was removed the next morning after awakening in the ICU. No neurological abnormalities such as clamping, disorientation, or mental disturbance was noted. Chemotherapy was continued postoperatively and the patient remains well at present after 3 years without evidence of recurrence.

Discussion

Since blood circulation must be occluded for the removal of tumors in the IVC or RA, either extracorporeal circulation or simple deep hypothermia is necessary. Extracorporeal circulation is used in many medical institutions for such cases [1–3]. The use of a cardiopulmonary bypass (CPB) allows unlimited duration of circulatory occlusion, but it has the disadvantage of increased blood loss and the risk of generalized metastasis from the venous system to the arterial system by tumor cell dissemination. Simple deep hypothermia is not popular for open heart surgery or other surgery, but there is no risk of hemorrhagic diathesis or of tumor cell dissemination into the arterial system, and there is less blood loss because of hypotension at the time of nephrectomy. The duration of circulatory occlusion, however, must be limited. Thus, the advantages and disadvantages of the two methods represent mirror images. In the present case, the patient was cooled to 20°C because the time required for the removal of the tumors in the RA and IVC had been estimated at 60 min. In view of the operative course and prognosis, the choice of hypothermia was correct. Standby of an artificial heart-lung machine in preparation for an unexpected extension of circulatory arrest was also justified. In a patient with this anomaly, however, a tumor embolism may reach the tricuspid valve, causing heart failure [4,5]. In heart failure patients, the use of hypothermia is difficult because they cannot be deeply anesthesized; therefore, a CPB would be the safer choice.

We have performed open heart surgery in more than 1500 children with the patients under simple deep hypothermia [6]. In addition to the required mastery of anesthetic techniques, we are fully aware of the usefulness, safety, and permitted duration of circulatory arrest.

Taking into consideration the possibility that the duration of circulatory arrest may reach the limit of tolerance as in the present case, blood pressure should be maintained at an adequate level for each degree of body temperature during anesthesia to protect organs such as the brain from hypoxic damage [7].

We concluded that simple deep hypothermia was better than a cardiopulmonary bypass for surgery of a Wilms' tumor with intracardiac growth. The reasons are as follows:

1. CPB involves the risk of metastasis of tumor cells from a vein to an artery.
2. Simple deep hypothermia is economical.
3. Simple deep hypothermia does not incur a risk of hemorrhage.
4. Surgery can be performed on the dry operative field using simple deep hypothermia.

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