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Anesthesia for Pediatric Stereotactic Radiosurgery

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STEREOTACTIC radiosurgery has become an important technique to treat various intracranial lesions in children.[1] Providing anesthesia for this therapy differs in several important ways from other "out of the operating room" procedures. First, the entire procedure can take 6-10 h and involves the placement of a bulky stereotactic frame around the head, imaging in the magnetic resonance imaging (MRI) suite (and sometimes in the neuroangiography suite), and transport to at least three different sites in the hospital. Finally, after the stereotactic frame is placed and the magnetic resonance image is obtained, the radiation oncologists require from 1 to 4 h to program the specific radiation therapy for a particular patient. Because the stereotactic frame must remain in place until the radiation is delivered, young infants and children must remain quiet to avoid displacing this frame. Thus, the patient remains "sedated" or anesthetized for a prolonged (often unpredictable) period before the radiation can be delivered. Finally, the anesthesiologist must be able to monitor the patient from outside of the room while the radiation is delivered. For the most part, infants and young children are unable to cooperate for such a complicated and lengthy therapy and, therefore, require general anesthesia or deep sedation to provide conditions that allow accurate imaging and precise delivery of radiation.

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Patient Selection

Between September 1991 and August 1994, 57 radiotherapy treatment sessions were performed in 52 patients (age range, 1-20 yr) using the Leksell Gamma Knife (Elekta Instrument SA, Geneva Switzerland). The average age of the 52 patients was 11 yr. Thirty-five sessions were performed during general anesthesia (mean age, 8 yr; 10 patients were aged 2-5 yr; 16 patients were aged 6-10 yr; 9 patients were aged 11-15 yr).

The time to complete both the diagnostic studies and to deliver the radiation treatment ranged between 300 to 855 min (mean, 491 ± 118 min). The duration of the radiosurgery was 60 to 505 min (mean, 187 ± 93 min).

Case Report

At the time of radiotherapy a 4-yr-old girl, who was diagnosed with extraosseous osteosarcoma 9 months before, developed left hemiparesis and new onset of seizures. MRI of the brain revealed a lesion in the right frontoparietal area. The patient underwent subtotal resection of the lesion, and pathologic examination revealed osteosarcoma in the mesenchymal tissue adjacent to the middle cerebral artery. She received phenytoin (Dilantin, Parke-Davis, Morris Plains, NJ) (to treat her seizure disorder) and an intense chemotherapy regimen consisting of cisplatinum (Platinol, Bristol-Myers Squibb Oncology/Immunology Division, Princeton, NJ), doxorubicin hydrochloride (Adriamycin, Pharmacia and Upjohn Company, Kalamazoo, MI), cytarabine (Cytosar-U, Pharmacia and Upjohn Company), and methotrexate (Methotrexate Sodium, Immunex, Seattle, WA). This unusual diagnosis was discussed at a multispecialty tumor board meeting, where it was recommended that the residual tumor be treated with radiotherapy.

The patient (weight, 15.8 kg) underwent broviac catheter placement. When she arrived at the MRI suite, propofol (Diprivan, Zeneca Pharmaceuticals, Wilmington, DE) was infused at a rate of 200 $\mu g \cdot kg^{-1} \cdot h^{-1}$ after an initial bolus of 20 mg was administered. Ventilation of the lungs with fluothane (Halothane, Wyeth-Ayerst Laboratories, Philadelphia, PA) and oxygen preceded intubation of her trachea. Local anesthesia (0.5% bupivacaine, [Marcaine, Sanofi Winthrop, NY]) was infiltrated before the stereotactic device was applied to the skull by the neurosurgeon. During MRI, adequacy of respiratory status was monitored by measuring oxygen saturation and end-tidal carbon dioxide (Omni-Trak 3100 MRI vital Signs Monitoring System, In vivo Research, Orlando, FL). Blood pressure and heart rate also were monitored. At the completion of the scan, the patient was transported from the MRI suite (third floor) to the postanesthesia care unit (PACU) (fourth floor), breathing spontaneously and receiving oxygen *via* the endotracheal tube.

For the next hour, the radiation oncologists analyzed the findings from the MRI and developed the precise plan for the stereotactic radiotherapy. The girl remained in the PACU, anesthetized with propofol (Diprivan) and monitored by the anesthesiologist. When the plan for radiotherapy was established, the patient was transported from the PACU (fourth floor) to the radiation oncology suite (basement floor) using the same technique for transport from the MRI suite to the PACU.

During delivery of the radiotherapy, the patient was positioned on a specific bed, and blood pressure, heart rate, oxygen saturation, and end-tidal carbon dioxide were monitored. Anesthetic equipment (*e.g.*, hoses, wires from monitors, intravenous tubing) was positioned precisely because the bed must be moved in various directions to allow proper angling of the patient for treatment. The patient and monitors were visualized *via* closed-circuit monitoring when the anesthesiologist was outside the room during the delivery of the radiation. Although an infusion of propofol (Diprivan) was the primary anesthetic delivered, an anesthesia machine was available during the radiotherapy. This allowed the anesthesiologist easy access to a mechanical ventilator and additional anesthetic agents.

At the completion of the radiotherapy, the patient's trachea was extubated, and she was transported back to the PACU, receiving supplemental oxygen by mask, and oxygen saturation was monitored en route. She was discharged to the ward 1 h later. The entire radiotherapy session (MRI to final discharge from the PACU) lasted 6 h, 15 min. She was discharged to home the next morning.

Discussion

Providing safe and efficient anesthesia for stereotactic radiotherapy in young children poses unique challenges for the anesthesiologist, the radiation oncologist, the neurosurgeon, and the radiologist. First, these young patients must be calm and "cooperative" for a long period. Second, the patients must be readily transported to multiple sites in the medical center. Third, medical personnel must remain outside the room during the delivery of radiation therapy.

For several reasons, the trachea usually is intubated before placement of the stereotactic frame. First, these patients have intracranial disease and may be particularly sensitive to hypoxia or severe hypercapnia as a complication of airway obstruction. Second, in the presence of the stereotactic device, stabilizing the neck and head to ensure a patent airway may be difficult. Third, after the stereotactic device is placed, intubating the trachea is possible but may be challenging, especially in young children and infants.

In general, the delivery of propofol (Diprivan) necessitates the presence of an anesthesiologist. The consequences of extubating the trachea or dislodging the frame are so significant that, in general, we have opted to maintain the depth of anesthesia established with propofol (Diprivan). The patient remains in the PACU from 1 to 3 h. The trend has been toward a decrease in the time needed for the manipulation of data necessary to obtain the calculations imperative to deliver the radiation.

Sedation techniques other than propofol (Diprivan) are available.[2–5] However, propofol (Diprivan) offers many advantages in this setting in which "light" but stable depth of anesthesia is desirable. We observed no untoward anesthetic events during these therapy sessions and have had no problems with prolonged sedation when propofol (Diprivan) was the sole agent used.

In addition to providing a constant level of anesthetic depth, a propofol (Diprivan) infusion offers additional advantages when a patient is transported to many sites to accomplish a complicated therapeutic schedule. Although an anesthesia machine is available at the MRI suite and at the radiation oncology site in our medical center, an infusion pump, emergency drugs, suction, a source of oxygen, and a device to administer positive pressure ventilation would provide a safe environment to supply anesthesia at these remote sites.

A closed-circuit television camera allows the anesthesiologist to view the patient's head and chest and the monitors on a screen from outside the radiotherapy room during the delivery of the radiation. This process is similar to that used for radiotherapy during general anesthesia for a variety of conditions: retinoblastoma, total body irradiation before bone marrow transplant, brain tumors.[6] However, during stereotactic radiotherapy, because the bed is moved in various directions to deliver the radiation, it is important to have monitors in a fixed position (*i.e.*, not on the moving bed) so the camera remains focused on the monitors and, therefore, visible to the anesthesiologist outside the room throughout the session.

In summary, providing a stable depth of sedation and anesthesia with a constant infusion of propofol (Diprivan) is an effective technique to accomplish a stereotactic radiotherapy session. The technique allows for easy transport among several sites in the course of the 6- to 10-h procedure and still allows prompt recovery.

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Third Degree Heart Block and Asystole Associated with Spinal Anesthesia

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CARDIAC arrest is a well-established complication of spinal anesthesia.[1-7] We present a case of spinal anesthesia-induced asystole in which onset and recovery could be recorded by means of Holter monitoring. Holter monitoring revealed that shortly after subarachnoid injection, a first degree heart block developed that, without any previous change in heart rate, progressed to a complete heart block. After successful resuscitation, a first degree heart block that persisted until 6 h after subarachnoid injection partly outlasted sensory and motor blockade.

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Key words: Asystole; complications; heart block; Holter monitoring; spinal anesthesia.

Case Report

A 68-yr-old patient was scheduled for elective total hip arthroplasty. Apart from arterial hypertension, treated with nifedipine, he had no history of cardiovascular disease. Physical examination and preoperative 12-lead electrocardiograph (ECG) revealed no abnormal condition. Premedication consisted of 7.5 mg oral midazolam administered 1 h before surgery. Intraoperative monitoring included pulse oximetry, noninvasive blood pressure measurement, and 2-lead ECG. On arrival in the operating room, blood pressure was 180/90 mmHg, and heart rate was 72 beats/min. A peripheral vein was cannulated, and 500 ml of Ringer's lactate solution was administered. The patient was turned to the left lateral decubitus position, and 4.0 ml of bupivacaine, 0.5%, in saline was injected into the subarachnoid space *via* a 22-gauge Quincke needle inserted at the L3-L4 interspace. Thereafter the patient was placed in the supine position. Approximately 5 min after the subarachnoid injection, the patient complained of nausea. Blood pressure at this time was 100/60 mmHg. Immediately thereafter a loss of consciousness followed by a tonic-clonic convul-