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Original article

Non-invasive anesthesia for children undergoing proton radiation therapy

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ABSTRACT

Background: Proton therapy is a newer modality of radiotherapy during which anesthesiologists face specific challenges related to the setup and duration of treatment sessions.
Purpose: Describe our anesthesia practice for children treated in a standalone proton therapy center, and report on complications encountered during anesthesia.
Materials and methods: A retrospective review of anesthetic records for patients ⩽18 years of age treated with proton therapy at our institution between January 2006 and April 2013 was performed.
Results: A total of 9328 anesthetics were administered to 340 children with a median age of 3.6 years (range, 0.4–14.2). The median daily anesthesia time was 47 min (range, 15–79). The average time between start of anesthesia to the start of radiotherapy was 7.2 min (range, 1–83 min). All patients received Total Intravenous Anesthesia (TIVA) with spontaneous ventilation, with 96.7% receiving supplemental oxygen by non-invasive methods. None required daily endotracheal intubation. Two episodes of bradycardia, and one episode each of; seizure, laryngospasm and bronchospasm were identified for a cumulative incidence of 0.05%.
Conclusions: In this large series of children undergoing proton therapy at a freestanding center, TIVA without daily endotracheal intubation provided a safe, efficient, and less invasive option of anesthetic care.

Proton therapy is a radiation modality gaining increasing popularity, particularly for the treatment of pediatric cancer patients. Particle therapy, including proton therapy has unique physical properties, which allow for the reduction or elimination of unnecessary dose to normal tissues. It is believed that reduced normal tissue exposure will translate into both decreased rates of both early and late treatment induced toxicities. As such, increasingly young patients are commonly referred, many of who require anesthesia given the need for prolonged immobilization with treatment sessions ranging from 30 to 90 min in length.

Several authors have described techniques for anesthetizing children undergoing conventional radiation therapy [1–6]. Anesthesia for proton therapy is unique due to the specific patient set up requirements and potentially longer duration of individual treatments. Moreover, currently the majority of proton therapy centers are not within inpatient facilities and as such the capacity for emergency response is limited.

There are a limited number of publications on the safety and techniques of providing anesthesia for proton therapy. Investigators from the Indiana University Health Proton center have described their initial experience, recording a low rate of anesthetic related complications at their offsite facility [7]. In their report, anesthesia was induced, a laryngeal mask airway (LMA) placed and anesthesia maintained using inhalational sevoflurane [7]. In contrast, investigators from the University's Children Hospital and the Paul Scherrer Institute in Switzerland reported on the use of propofol sedation in 10 pediatric patients treated with proton therapy without placement of an artificial airway [8,9]. Such an approach avoids repeated daily instrument-induced irritation of the airway and facilitates immobilization with thermoplastic masks. Additional benefits of avoiding artificial airways may include a reduction in the total amount of anesthetic necessary to maintain adequate sedation and decreased overall room time.

As new proton centers continue to emerge, there is a need for further publications describing the anesthetic management for

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children undergoing proton therapy. The primary objective of our study was to review and describe the anesthetic management of children undergoing proton radiation therapy at our center and report on anesthesia-related complications.

Materials and methods

After approval by the University of Texas MD Anderson Cancer Center Institutional Review Board, we retrospectively reviewed the records of children 18 years of age and younger treated with proton therapy between September 2006 and April 2013. Patient demographics, medical history, site of irradiation, number of anesthetic sessions and route of administration were recorded. Airway management, medications administered, duration of anesthetics, and major complications occurring during anesthesia were recorded. Major complications were defined as the following: cardiopulmonary resuscitation, urgent intubation, unexpected admission to the hospital, the administration of epinephrine or atropine, laryngospasm, pulmonary aspiration, and bronchospasm. Coughing, which required suctioning, and brief spells of apnea or desaturation were not classified as major complications. Likewise, episodes of hypotension or bradycardia, which did not require the administration of epinephrine or atropine, were not classified as major complications.

Anesthetic personnel and patient management

The proton therapy center is a standalone facility located one mile from the main MD Anderson Hospital Campus. The anesthesia team consists of a physician with pediatric anesthesia expertise and a Certified Registered Nurse Anesthetist (CRNA). Other medical personnel at the facility include; radiation oncologists, radiation therapists, and registered nurses. Referrals for proton therapy under anesthesia are based on the age of the patient, prior history of requiring anesthesia for imaging, the emotional maturity of the child, and the duration and site of treatment. We treat a number of international patients at our proton therapy center, and we have noted anecdotally that European patients above the age of 5 years often do not require anesthesia. It is however not uncommon for North American children over the age of 7 to undergo these procedures under anesthesia. In the event that anesthesia is not required, child life specialists are on hand to provide care with the aid of various toys and distraction techniques.

All patients requiring anesthesia have a pre-anesthesia evaluation prior to sedation. Anesthetic risks for the procedure with regard to the current cardiopulmonary, neurological, endocrine and immune status of the patient are assessed. The risk of airway compromise and previous and current chemotherapy regimens are also assessed. Bearing in mind that a change in airway management may alter the radiation treatment plan and also require re-simulation, several factors were taken into consideration in the decision to use an unprotected airway. The decision to use an unprotected airway was based on an adequate cardiopulmonary status, the absence of obstructive airway lesions, and the ability of the patient to adequately clear oropharyngeal secretions when awake. A history of obstructive sleep apnea was a contraindication to non-invasive airway management. Prone positioning and radiation to the head and neck area did not serve as a contraindication to unprotected airway management. The appropriateness of non-invasive airway management was continuously assessed over the duration of treatment. Close collaboration and communication with the primary care team is essential to ensure uninterrupted chemo and radiotherapy sessions and also to acquire updates on the patients' condition. Despite the majority of our patients being American Society of Anesthesiologists (ASA) risk class 3 or higher, all patients referred for anesthesia evaluation were allowed to undergo treatment under anesthesia. None were referred for alternate methods of care based on anesthetic concerns.

Fasting instructions according to the current ASA guidelines were provided. This typically requires no solids by mouth for 8 h, 6 h for milk and 4 h for breast milk. Clear fluid intake was encouraged for up to 2 h prior to treatment. An effort was made to treat younger children earlier in the day, since they are more prone to dehydration and less tolerable of the fasting guidelines.

In general, each patient undergoes a simulation first followed by 10–33 daily proton treatments given Monday to Friday, each requiring sedation. Each session can last between 30 and 90 min depending on the complexity of the treatment set up and delivery. Patients who do not have central venous access were referred for surgical placement of such a line before the start of treatment. The majority of our patients are treated on an out-patient basis, and not routinely admitted to the hospital for post anesthetic or post radiotherapy care.

In the absence of specific contraindications or airway concerns, induction of anesthesia and access of central lines is carried out on the treatment table (or computed tomography simulator suite) with the patient awake and seated on the parent's lap. Due to the immunocompromised status of many patients central line access and handling was performed with strict sterile precautions. A child life specialist was present during induction and central line access to distract and comfort the child with toys and video games. Standard ASA monitors (electrocardiography, pulse oximetry, non-invasive blood pressure, and capnography) were placed. Our anesthetic management of choice is Total Intravenous Anesthesia with the patient spontaneously breathing. The induction and maintenance drug of choice is propofol. Induction and maintenance doses of propofol were titrated to individual patient requirements. Dexmedetomidine or narcotics were added when there was excessive patient movement despite higher than average doses of propofol. The depth of anesthesia was guided by hemodynamic parameters and the extent of patient movement during positioning. Bispectral Index monitoring of the depth of anesthesia is not utilized since the probe may interfere with the treatment field. Anti-emetics were routinely administered after induction. Thermoplastic immobilization masks are placed after an appropriate depth of anesthesia is established and supplemental oxygen was administered by nasal cannula or facemask.

At the time of simulation, thermoplastic masks were fabricated in such a way as to elevate the patient's chin, thereby promoting an open airway. During molding of the mask, orifices for placement of a nasal cannula are created. Alternatively, following fabrication of the mask, small sections are removed to allow for cannula placement, while respecting mask integrity. For treatments sessions, patients were secured to the treatment table with the aid of straps across their body and covered with a warm blanket. Cameras are positioned to allow visualization of the patient as well as monitors from the treatment control room. After the completion of treatment patients were transported to the recovery area staffed by a trained recovery room nurse. Standard monitoring was continued until the patient was awake, alert, hemodynamically stable, and tolerating oral intake if desired. Duration of stay in the recovery area was variable since most children were allowed to wake up spontaneously and feed in the recovery room. The staff anesthesiologist remained at the treatment facility until the last patient is discharged from the recovery area.

Radiotherapy and chemotherapy specific anesthetic concerns

A significant number of children receiving radiotherapy may have or be receiving concurrent chemotherapy. In addition to the well documented side effects of chemotherapy, gastrointestinal (GI) and hematologic toxicities are may be encountered during

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