Age as a decisive factor in general anesthesia use in pediatric proton beam therapy.

YUZO SHIMAZU (yuzo0806@gmail.com)
Southern TOHOKU General Hospital
Rie Otsuki
Southern TOHOKU General Hospital
Masao Murakani
Southern TOHOKU Proton Therapy Center
Akio Konishi
Southern TOHOKU General Hospital
Keiichi Kan
Southern TOHOKU General Hospital
Ichiro Seto
Southern TOHOKU Proton Therapy Center
Hisahi Yamaguchi
Southern TOHOKU Proton Therapy Center
Masaharu Tsubokura
Department of Public Health, Fukushima Medical University School of Medicine
Hisashi Hattori
Southern TOHOKU General Hospital

Research article

Keywords: Pediatric proton therapy, general anesthesia, propofol, airway management, laryngeal mask

Posted Date: December 11th, 2019

DOI: https://doi.org/10.21203/rs.2.18539/v1

Abstract

Background: Proton therapy for pediatric cancer patients is effective treatments. Young children have difficulties staying still during irradiation, so general anesthesia is often required. This study investigated the indication for general anesthesia in pediatric proton therapy.

Methods: We focused on cancer patients under 15 years old who underwent proton therapy at Southern TOHOKU General Hospital, Fukushima, Japan from April 2016 to December 2018. Background information and anesthesia/treatment protocols were retrospectively extracted from the electronic medical record. The anesthesia and non-anesthesia group were compared to evaluate factors determining the need for general anesthesia .

Results: We analyzed 32 patients who received 285 irradiations. The median age was 5 years old (range: 1–15), and 13 patients (40.6%) were female. Twelve (37.5%) patients were treated with general anesthesia. In the general anesthesia group, airway management using laryngeal mask was performed in 11 patients (91.6%). Age was significantly lower in the general anesthesia group than in the non-anesthetized group ($p < 0.001$). Considering all background factors, only age was strongly associated with anesthesia in the univariate logistic regression models: odds ratio 0.55 [95% confidence interval 0.35–0.86] ($P < 0.01$). Adverse events included nausea and vomiting during and after irradiation, and no fatal complications were observed.

Conclusion: Age is one of the most important factors determining the need for general anesthesia for PBT in children. it will be necessary to determine the guidelines for accumulation and collection of data between institutions and the indication of general anesthesia/sedation for radiation therapy including PBT.

Background

General anesthesia is an essential measure for performing invasive treatment, by putting the patient in a non-physiological state via administration of an anesthetic. Subjects who undergo general anesthesia range from prenatal neonates to elderly people over 100 years of age. The number of cases requiring general anesthesia has recently tended to increase with an increase in cancer patients, with cerebrovascular disease and with changes of disease structure. According to the 2008 report, more than 200 million operations under general anesthesia were performed worldwide(1). Under such circumstances, the need for anesthesia outside the operating room is rapidly increasing. Treatments requiring general anesthesia besides surgical operation include cardiovascular catheterization such as ablation, stent graft interpolation, endovascular treatment, radiological embolization, gamma knife and proton beam therapy (PBT)(2). Performing general anesthesia outside the operating room raises safety and quality issues due to the limited availability of equipment and anesthesiologists, who might not be available in case of an emergency(3, 4).

With the advances in radiation therapy technology, PBT emerged as a promising treatment for cancer. The therapeutic effects of PBT in childhood cancer, especially brain tumors and neuroblastoma, are high and its application is on the rise worldwide(5–7). Because PBT for children requires a longer immobilization period during irradiation compared with general radiation therapy, general anesthesia and sedation may be required for immobilization(8). Therefore, cooperation between radiologists and anesthesiologists is important for patients who need general anesthesia or sedation. However, since it is necessary to perform this procedure several times every day, it is important to properly select subjects considering the risks. On the other hand, while several researchers have reported on the safety and efficacy of general anesthesia during PBT, there is a lack of evidence on the safety of repeated anesthesia and sedation during PBT in children(9–11). The reports lack information on the equipment standards used for safe general anesthesia management, and there was not enough information on how treatment choices were made at each facility.

As of July 1, 2019, in Japan, one million people develop cancer every year, and in total 300,000 patients are reported to receive radiation treatment each year, of which 4,000 to 5,000 patients (1.2%) are receiving PBT in 19 proton beam facilities. In Japan, health insurance for PBT has been rapidly implemented, with pediatric tumors covered by insurance in 2016 and head & neck cancers excluding squamous cell tumor of oral cavity or pharynx, prostate cancer and bone and soft tissue sarcoma in 2018. Almost 30 to 40% of PBT patients are covered by insurance and the remaining are covered by advanced medical services regulated by the Ministry of Health, Labor and Welfare. Given that PBT has a high therapeutic effect (high local control rate and low damage to normal tissue) and is covered by insurance for childhood cancer, the number of treatments is expected to increase as an option for radiation therapy. Diseases currently considered for PBT in Japan include various tumors arising from the brain, head and neck, lung, esophagus, mediastinum, liver, pancreas, kidney, bladder, prostate and bone and soft tissue in adult, and childhood cancers mainly include brain tumor, extra-cranial sarcomas, neuroblastoma and hematopoietic tumors(12, 13).

The Southern TOHOKU General Hospital is a general hospital with 460 beds and 26 medical departments in Koriyama City, Fukushima prefecture (population density: 440 people/km^2, in the Tohoku region the third population: 332,863 people), Japan. Our hospital has 159 doctors, and we offer not only cancer treatment but also cerebrovascular disorder, cardiovascular disease and pediatric perinatal care. The diagnostic equipment includes computed tomography (CT), magnetic resonance imaging (MRI), and positron emission tomography of 5 units each, and for radiotherapy, we have several modalities including cyber knife, gamma knife, liner accelerators, remote after loading system, and PBT system. The number of outpatients per year is 350,000, and about 2,000 new cancer patients are registered for cancer every year. Approximately 3% of the patients were referred from overseas in 2018. Southern TOHOKU Proton Therapy Center opened its doors in October 2008 as the first private particle therapy facility in Japan. It has performed PBT on a total of 5,000 people from October 2008 till August 2019. There are 10 dedicated radiation oncologists and 3 anesthesiologists actively performing PBT for childhood cancer. The requirement of sedation is discussed prior to the start of the treatment for each individual patient to ensure proper treatment(14). This situation enabled us to collect retrospectively information available from cases from the Southern TOHOKU General Hospital to know which patients to sedate and which patients not to sedate.

In order to examine the indications for general anesthesia for pediatric PBT, information on patients under 15 years of age was extracted retrospectively (age, body weight, primary disease, radiation therapy and general anesthesia) and was compared between groups that required general anesthesia and groups that did not require general anesthesia.

Methods

Ethics

For the present study, we obtained inclusive consent from the parents/guardians of patients. This study was approved by the institutional review board of Southern Tohoku Research Institute for Neuroscience Southern TOHOKU General Hospital (Authorization number 378).

Study setting

This study (Proton therapy) was a retrospective observational study which was conducted at Southern TOHOKU Proton Therapy Center (Koriyama City, Fukushima Prefecture in Japan). This machine (manufactured by Mitsubishi Corp.) consists of a synchrotron accelerator, two gantries and one fixed horizontal beam line. The synchrotron system can deliver passively scattered protons at a range of energies up to 235 MeV.

Patients and variables

We targeted pediatric patients (age 15 years old or younger) who underwent PBT at our hospital from April 2016 to December 2018. The patients were introduced by the Department of Pediatric Oncology, Fukushima Medical University. Using the database of electronic medical record system at our hospital, age, gender, body mass index (BMI), primary disease diagnosis, performance status (PS) (0–4), and details of treatment before PBT (chemotherapy, other radiotherapy, presence or absence of surgery) were extracted for each patient. Regarding treatment, information was extracted on the irradiation site, the irradiation dose, the number of irradiations, the number of irradiation days, and the presence or absence of anesthesia (general anesthesia, including sedation, or no anesthesia).

Anesthesia management

In order to determine whether general anesthesia or sedation is necessary during PBT, anesthesiologists participated in CT imaging during treatment planning. Propofol was administered to the patient during treatment planning to assess airway obstruction and respiratory depression to ensure the safety of the patient's airway during irradiation.

When the anesthesiologist determined that the patient had to maintain an open airway during treatment, fentanyl was injected intravenously to insert the laryngeal mask airway (LMA), and the patients that maintained spontaneous breathing were given sevoflurane during irradiation.

Analysis

In order to assess the indications for general anesthesia for pediatric PBT, we performed the following two analyses:

1. First, to identify the differences in background characteristics between the presence or absence of anesthesia groups, the following variables were compared: Chi-square tests were used for categorial variables, and t-tests were used for continuous variables.

2. Second, to identify the factors associated with the indications for general anesthesia, we constructed a multivariate logistic regression model. The outcome variable was dichotomous (i.e., the presence of general anesthesia including sedation versus no general anesthesia). Potential covariates considered in the model were: age, sex, disease (brain tumors or others), PS (0–1 or >=2), pre-treatment, and the number of irradiation sites (single or multiple sites). The variable selection was based on univariate analyses.

All analyses were performed using Stata/IC version 15.0 (StataCorp LP). P-values < 0.05 were considered statistically significant.

Results

In this study, we included 32 patients from our hospital (Table 1). The median age was 5 years (range: 1–15 years), including 19 male (59.4%) and 13 (40.6%) female. The median BMI was 16.7 (range: 13.3–32.0) kg/m^2. Thirteen patients had brain tumors, which included 5 with medulloblastoma, 4 with glioma, 2 with ependymoma, 1 with germinoma and intraventricular tumor. The number of patients with non-brain tumor was: 9 with neuroblastoma, 3 with rhabdomyosarcoma , 2 with AML extramedullary, 1 with B cell lymphoma, Ewing's sarcoma, myofibroblastoma, buccal mucosal schwannoma, retroperitoneal tumor.

The median of PS before PBT was 1 (range: 0–4). The total number of irradiations was 285 times with the median number of treatment duration of 22.5 days. The median of irradiation dose was 50.4 (range: 19.8–66.0) Gy. While 13 patients were irradiated at multiple locations, the number of irradiation site was the 16 inside the cranium, 5 in the head and neck, 12 in the spinal cord, 3 in the chest, 11 in the abdomen and retroperitoneum, and 2 in others. The primary site of irradiation was 13 inside the cranium ,1 in the spinal cord, 5 in the head and neck, 8 in the abdomen and retroperitoneum, and 5 in others (femur or sacral bones). In the group who underwent general anesthesia, patients significantly were younger than those without general anesthesia (P<0.001) (Table 1). There were no statistical differences in backgrounds other than age between the two groups. The oldest in the group who received anesthesia was 7 years old: A 7-year-old child with glioblastoma and autism was unable to stay still and underwent general anesthesia, whereas a 3-year-old child was quiet and had a short treatment time, therefore he could be irradiated without general anesthesia. On the contrary, the youngest in the group that did not receive anesthesia was 3 years old.

As for the method of anesthesia, 12 people (37.5%) underwent general anesthesia/sedation (Table 2). Airway management using LMA was performed in 11 people (91.6%). Propofol alone was used in one patient. The median dose of propofol was 30 mg (range: 8–50 mg), that of fentanyl was 30 mg (range: 0–72 mg), and the median concentration of sevoflurane was 1.5% (range: 0–3.0%). The median time to awakening from anesthesia was 21 minutes (range: 5–52 minutes), and the median time in the treatment room was 45 minutes (range: 15–70 minutes) (Table 2).

Results of the logistic regression analyses for the indication of general anesthesia were shown in Table 3. Due to a lack of significant variables (except for age), we could not construct a multivariate regression model for the indications for general anesthesia. Thus, Table 3 presents the results of the univariate logistic regression models. We found statistically significant association between age and the indication for general anesthesia: odds ratio (OR) 0.55 [95% confidence interval (CI) 0.35–0.86] ($P < 0.01$). Other variables were not significantly associated with the indication for general anesthesia.

In terms of side effects related to general anesthesia, aspiration and vomiting after irradiation were observed in one (8.3%) out of 12 patients due to bulbar palsy caused by the underlying disease. Movement and severe hypoxemia during irradiation were not observed in any case.

Discussion

In recent years, the number of general anesthesia has tended to increase in and outside of the operating room due to increase with an increase in cancer patients, with cerebrovascular disease and with changes of disease structure. While there are many reports on PBT showing high therapeutic results in cancer treatment(15, 16), a high-level treatment plan is required for highly accurate treatment, which requires time for proper alignment, immobilization during irradiation, and general anesthesia or sedation to suppress body movement. Given that general anesthesia and sedation need to be performed several times daily, it is important to properly select subjects at risk. While it has been considered safe for PBT to be performed under general anesthesia in children, little information is available on the indications for general anesthesia among patients who receive PBT.

This study has shown that age is one of the most important factors determining the need for general anesthesia for PBT in children. According to the data, the median age was 3 years in the group where general anesthesia was performed, while the median age was as high as 8.5 years in the group where general anesthesia was not performed. In particular, the oldest in the group who received anesthesia was 7 years old, while the youngest in the group that did not receive anesthesia was 3 years old. Vigneron et al.(9) reported that children under 4 years of age required general anesthesia during radiation therapy. On the other hand, McMullen KP et al. (10) reported the need for general anesthesia in almost all children under 3 years old, about half in 7–8 years old and about 10% in 12 years or older. In addition, Pascal Owusu et al. (17) reported the need for general anesthesia and sedation in 72% of patients under 4 years old, 45% from 4 to 6 years old, 15% at 7–10 years old, and 6% at 10 years or older. In the present study, there is a clear difference in average age between the two groups, and there is a tendency similar to the previous reports. Currently, there is a consensus on general anesthesia for children under 3 years of age during radiation therapy (11). However, for children aged 7–8 years, the criteria for general anesthesia between institutions are ambiguous and there is no consensus. While age is a very important factor in determining general anesthesia indications, Mizumoto et al. (18) reported that even children aged 4 to 6 years were able to significantly shorten the irradiation time without general anesthesia by actively adjusting the treatment environment and performing interventions before PBT. In the future, it will be necessary to determine the guidelines for accumulation and collection of data between institutions and the indication of general anesthesia/sedation.

The present study showed that the safety of PBT under general anesthesia was sufficiently maintained in children under 15 years of age. From the 12 children irradiated under general anesthesia there was only 1 (8.3%) adverse effect of anesthesia. This data is similar to previous reports (19–22). On the other hand, at the time of general anesthesia, it is necessary to discuss whether airway securing is necessary for proper safety. In fact, 91.6% of cases in this study required the insertion of LMA, and during irradiation, anesthesia management that preserved spontaneous breathing by sevoflurane inhalation was the first choice. As for the cases repeated in our hospital, it was found that propofol alone could be used to reduce physical activity without the need for LMA management (1 example). In the previous report, Owusu-Agyemang et al. (11) performed a total of 9,430 proton treatments in 340 patients and performed intravenous anesthesia (sedation) only with propofol in all patients. As a result, although LMA was inserted in 2 cases due to the decrease in oxygen saturation, it was reported that 97.3% of cases could be managed without securing the airway. Therefore, it is possible that anesthesia and sedation management can be performed without inserting the LMA and securing the airway, and it is necessary to accumulate data on the difference in safety depending on the presence or absence of secured airway.

Although it may be possible to perform PBT with general anesthesia/sedation without securing the airway, there are problems with respiratory depression, apnea, and airway obstruction due to tongue base depression (23). It cannot be asserted whether airway patency can be maintained when propofol is administered in a sufficient amount to suppress movement. There are various ways to secure propofol management. First, the use of an electroencephalogram monitor (BIS monitor) (24) as an indicator of objective sedation during propofol administration may be effective, but it is desirable to develop new techniques and devices for evaluating airway patency in children with various responses to sedation. Second, regarding treatment and anesthesia equipment, during PBT, the treatment room and control room are completely isolated as in the MRI examination. Therefore, it is essential for management to install equipment for patient monitoring and vital equipment to measure tidal volume and respiratory rate accurately, including an exhaled carbon dioxide monitor (25–27). Manpower, education and maintenance of doctors and other medical staff are also desired. Third, there are no clear safety standards for personnel, monitors, and facilities during radiation therapy, and conditions vary among facilities.

Although the costs of investment in safety equipment vary, it is desirable to develop common guidelines for safety equipment.

Limitation

The limitation of this study is that it is a retrospective study at a single institution, with a small number of registered cases, and that anesthesia data and nursing records were extracted based on the electronic medical record system, with data missing.

Conclusion

Age is one of the most important factors determining the need for general anesthesia for PBT in children. While the safety of PBT under general anesthesia was sufficiently maintained in children under 15 years of age, in order to perform PBT with general anesthesia/sedation without securing the airway it will be necessary to determine the guidelines for accumulation and collection of data between institutions and the indication of general anesthesia/sedation.

Declarations

Ethics approval and consent to participate

In the present study, we have obtained inclusive consent from the parents of patients

(under the age of 16 years old) . This study was approved by the institutional review board. (Authorization number- 378)

Consent for publication

We used your consent form for publication.

Availability of data and material

Not apllicable

Competing interests

non-financial competing interests

Funding

No funding was obtained for this study

Authors' contributions

YS, RO, MM, AK, KK, IS, HY, MT, HH

Acknowledgments

We thank Mr. Masaki Suzuki at Southern TOHOKU Proton Therapy Center, and Southern Tohoku Research Institute for Neuroscience Southern TOHOKU General Hospital for their support with data collection and management. Without his involvement, our study could not have reached its present form. We also express our gratitude to the staff in Southern TOHOKU Proton Therapy Center, Southern Tohoku Research Institute for Neuroscience Southern TOHOKU General Hospital. We would like to thank Editage (www.editage.com) for English language editing.

Abbreviations

PBT: proton beam therapy

References

1. Weiser TG, Regenbogen SE, Thompson KD, Haynes AB, Lipsitz SR, Berry WR, et al. An estimation of the global volume of surgery: a modelling strategy based on available data. Lancet (London, England). 2008;372(9633):139-44.
2. Fuchs-Buder T, Settembre N, Schmartz D. [Hybrid operating theater]. Anaesthesist. 2018;67(7):480-7.
3. Choi JW, Kim DK, Lee SH, Shin HS, Seong BG. Comparison of Safety Profiles between Non-operating Room Anesthesia and Operating Room Anesthesia: a Study of 199,764 Cases at a Korean Tertiary Hospital. J Korean Med Sci. 2018;33(28):e183.
4. D.Miller R. Miller’s Anesthesia. 2005;SIX EDITION:47.
5. Baliga S, Yock TI. Proton beam therapy in pediatric oncology. Current opinion in pediatrics. 2019;31(1):28-34.
6. Vogel J, Both S, Kirk M, Chao HH, Bagatell R, Li Y, et al. Proton therapy for pediatric head and neck malignancies. Pediatric blood & cancer. 2018;65(2).
7. Glaser A, Nicholson J, Taylor R, Walker D. Childhood cancer and proton beam therapy. BMJ (Clinical research ed). 2014;349:g5654.
8. McFadyen JG, Pelly N, Orr RJ. Sedation and anesthesia for the pediatric patient undergoing radiation therapy. Current opinion in anaesthesiology. 2011;24(4):433-8.
9. Vigneron C, Schwartz E, Troje C, Niederst C, Meyer P, Lutz P, et al. [General anesthesia in pediatric radiotherapy]. Cancer radiotherapie : journal de la Societe francaise de radiotherapie oncologique. 2013;17(5-6):534-7.
10. McMullen KP, Hanson T, Bratton J, Johnstone PA. Parameters of anesthesia/sedation in children receiving radiotherapy. Radiation oncology (London, England). 2015;10:65.
11. Owusu-Agyemang P, Grosshans D, Arunkumar R, Rebello E, Popovich S, Zavala A, et al. Non-invasive anesthesia for children undergoing proton radiation therapy. Radiotherapy and oncology : journal of the European Society for Therapeutic Radiology and Oncology. 2014;111(1):30-4.

12. JAPAN AFNTIMI. Introduction of Japanese particle radiotherapy facilities. March, 2019.
13. Oncology JJSfR. Disease for proton beam therapy. March 2018.
14. Shimazu Y, Hattori, H, Adachi, K, OTSUKI, R, Konishi A. Approach of pediatric proton therapy with sevoflurane general anesthesia. Journal od Clinical Anesthesia (Japan). 2018;42(2018):No.12(2018-12).
15. Mizumoto M, Murayama S, Akimoto T, Demizu Y, Fukushima T, Ishida Y, et al. Long-term follow-up after proton beam therapy for pediatric tumors: a Japanese national survey. Cancer science. 2017;108(3):444-7.
16. Journy N, Indelicato DJ, Withrow DR, Akimoto T, Alapetite C, Araya M, et al. Patterns of proton therapy use in pediatric cancer management in 2016: An international survey. Radiotherapy and oncology : journal of the European Society for Therapeutic Radiology and Oncology. 2019;132:155-61.
17. Owusu-Agyemang P, Popovich SM, Zavala AM, Grosshans DR, Van Meter A, Williams UU, et al. A multi-institutional pilot survey of anesthesia practices during proton radiation therapy. Practical radiation oncology. 2016;6(3):155-9.
18. Mizumoto M, Oshiro Y, Ayuzawa K, Miyamoto T, Okumura T, Fukushima T, et al. Preparation of pediatric patients for treatment with proton beam therapy. Radiotherapy and oncology : journal of the European Society for Therapeutic Radiology and Oncology. 2015;114(2):245-8.
19. Verma V, Beethe AB, LeRiger M, Kulkarni RR, Zhang M, Lin C. Anesthesia complications of pediatric radiation therapy. Practical radiation oncology. 2016;6(3):143-54.
20. Gonzalez LP, Pignaton W, Kusano PS, Modolo NS, Braz JR, Braz LG. Anesthesia-related mortality in pediatric patients: a systematic review. Clinics (Sao Paulo, Brazil). 2012;67(4):381-7.
21. Grebenik CR, Ferguson C, White A. The laryngeal mask airway in pediatric radiotherapy. Anesthesiology. 1990;72(3):474-7.
22. Buchsbaum JC, McMullen KP, Douglas JG, Jackson JL, Simoneaux RV, Hines M, et al. Repetitive pediatric anesthesia in a non-hospital setting. International journal of radiation oncology, biology, physics. 2013;85(5):1296-300.
23. Khurmi N, Patel P, Koushik S, Daniels T, Kraus M. Anesthesia Practice in Pediatric Radiation Oncology: Mayo Clinic Arizona's Experience 2014-2016. Paediatric drugs. 2018;20(1):89-95.
24. Kamata K, Hayashi M, Nagata O, Muragaki Y, Iseki H, Okada Y, et al. Initial experience with the use of remote control monitoring and general anesthesia during radiosurgery for pediatric patients. Pediatric neurosurgery. 2011;47(2):158-66.
25. pediatrics JSf, Anesthesia JAoP, Society Jpr. Joint proposal on sedation during MRI examination in Japanese. 2013.
26. Godwin SA, Burton JH, Gerardo CJ, Hatten BW, Mace SE, Silvers SM, et al. Clinical policy: procedural sedation and analgesia in the emergency department. Annals of emergency medicine. 2014;63(2):247-58. e18.

27. Whitaker DK, Benson JP. Capnography standards for outside the operating room. Current opinion in anaesthesiology. 2016;29(4):485-92.

Tables

Table 1. Children's characteristics

		Overall	General anesthesia Yes	No	p values
		n = 32	12	20	
Age (years)	median, range	5 (1–15)	3 (1–7)	8.5 (3–15)	P<0.001
Age category	0–3	10	6 (60%)	4 (40%)	P<0.01
	4–7	11	6 (54.5%)	5 (45.5%)	
	8–15	11	0 (0%)	11 (100%)	
Sex	Male	19	8 (42.1%)	11 (57.9%)	0.52
	Female	13	4 (30.8%)	9 (69.2%)	
BMI (kg/m^2)	median, range	16.7 (13.3-32.0)	16.3 (13.6–20.3)	17.5 (13.3-32.0)	0.20
Disease Brain tumor	Medulloblastoma	5	3 (60%)	2 (40%)	0.78
	Glioma	4	1 (25%)	3 (75%)	
	Other brain tumor	4	1 (25%)	3 (75%)	
Non-brain tumor	Neuroblastoma	9	5 (55.6%)	4 (44.4%)	
	Rhabdomyosarcoma	3	1 (33.3%)	2 (66.7%)	
	AML extramedullary	2	1 (50%)	1 (50%)	
	Other	5	0 (0%)	5 (100%)	
Pre-treatment	Radiation	20	7 (35%)	13 (65%)	0.71
	Chemotherapy	11	4 (36.4%)	7 (63.6%)	0.92
	Operation	19	9 (47.4%)	10 (52.6%)	0.16
Irradiation site	Intracranial	16	7 (43.7%)	9 (56.3%)	0.47
	Head and neck	5	2 (40%)	3 (60%)	0.90
	Spinal cord	12	6 (50%)	6 (50%)	0.26
	Chest	3	0 (0%)	3 (100%)	0.16
	Abdomen and Retroperitoneum	11	5 (45.5%)	6 (54.6%)	0.50
	Other	2	1 (50%)	1 (50%)	0.71
Primary site of irradiation	Intracranial	13	6 (46.2%)	7 (53.8%)	0.58
	Head and neck	5	1 (20%)	4 (80%)	
	Chest	0	0 (0%)	0 (0%)	
	Spinal cord	1	0 (0%)	1 (100%)	
	Abdomen and Retroperitoneum	8	4 (50%)	4 (50)	
	Other	5	1 (20%)	4 (80%)	

Dose (Gy)	median, range	50.4 (19.8–66.0)	45.2 (19.8–61.2)	50.4 (19.8–66.0)	0.73
Number of treatment days	median, range	22.5 (10-33)	20.0 (10–33)	25.0 (11–33)	0.58
Adverse side effect		1	1 (8.3%)	0	

P-values for chi-square test and t-test for comparisons between general anesthesia group and non-general anesthesia group

Table 2. Characteristics of general anesthesia/sedation

Airway securing		
Yes (using Laryngeal mask)	11	91.7%
No	1	8.3%
Anesthetic	Median	Range
Propofol dose (mg)	30	8–50
Fentanyl dose (µg)	30	0–72
Sevoflurane concentration (%)	1.5	0–3.0
Adverse side effect (n=1)		
Body movement	0	0%
Hypoxia	0	0%
Nausea and vomiting	1	3.1%
Other	0	0
	Median	Range
Time to awakening (min)	21	5–52
Irradiation time (min)	29	14–75
Time in the irradiation room (min)	40	25–79

Table 3. Results of univariate analyses: odds ratio for factors associated with general anesthesia (95% confidence interval)

	Odds ratio	95% confidence interval
Age (years)	0.55	0.36−0.85[*]
Sex		
male	1.00	
female	0.61	0.14-2.71
Disease		
Brain tumors	1.00	
others	0.93	0.22-4.00
Primary site of irradiation		
Intracranial	1.00	
Other site	1.86	0.43−7.98
Performance Status		
0−1	1.00	
≧ 2	0.58	0.14-2.48
Irradiation site single	1.00	
multiple	3.27	0.73-14.6
Pre-treatment		
Chemotherapy −	1.00	
+	0.93	0.20−4.21
Operation −	1.00	
+	2.41	0.62−14.5
Radiation −	1.00	
+	0.75	0.17−3.28

[*]P < 0.01