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Anaesthesia for radiation therapy – Gliwice experience.

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General anaesthesia is rarely applied during fractionated radiotherapy with the exception of unco-operative patients. We performed a retrospective study to inform our current practice in anaesthesia procedures for radiotherapy application in children, brachytherapy and intraoperative radiation. The records of anaesthetized radiotherapy patients between January 2000 and September 2005 were analyzed. We analysed demographic data, type and localisation of neoplasm , radiotherapy data, type of anaesthesia and anaesthesia – related complications. In order to provide safe and efficient anaesthesia outside the Department of Anaesthesiology, we designed a mobile anaesthesia workstation. In total we performed 739 anaesthesia procedures: 267 in 16 children, 321 in 284 brachytherapy patients, and 151 as a part of intraoperative radiotherapy. Children age ranged from 2 – 8 years (median 4.6). All were given midazolam and atropine, then thiopental or ketamine. Neither muscle relaxants, nor propofol were used. Brachytherapy patients underwent: spinal block in 190 cases, general anaesthesia in 115, and deep sedation in 16 cases. General anaesthesia was inducted by propofol, followed by etomidate, thiopental and fentanyl. For spinal block the patients were given hyperbaric bupivacaine and fentanyl. Deep sedation was performed with midazolam and fentanyl, and thiopental or propofol when needed. Intraoperative radiotherapy was applied immediately after breast conserving surgery. No serious complications in all 739 anaesthesia procedures occurred. In conclusion we demonstrated the feasibility and safety of anaesthesia applied in our radiotherapy patients. The custom designed mobile anaesthesia workstation allowed us to provide safe and efficient anaesthesia in any place outside the Department of Anaesthesiology.

Key words: *anaesthesia for radiotherapy, paediatric radiotherapy, brachytherapy, intraoperative radiotherapy, childhood cancers.*

Traditionally anaesthesiologists are specially trained to provide anaesthesia and care for patients during surgery, in critical care units and to provide pain management. Their particular responsibility for patients' lives during surgical procedures requires constant presence at a patient's table, direct observation and continuous monitoring of life parameters.

In modern radiation oncology, anaesthesia plays an increasingly important role. Sophisticated techniques of irradiation and tumour location reducing normal tissue margins to a minimum are of no use if the patient cannot stay still throughout the whole irradiation. This applies to techniques of radiotherapy like brachytherapy, intraoperative irradiation and external beam treatment of unco-operative patients, for example young children or mentally disabled persons. The techniques deal with specific problems for anaesthesiologists. The care is usually provided in the shielding room which requires special modification in anaesthesia equipment. During radiation exposure a patient is left alone in the shielding room and observed via a camera and monitors [1, 2].

In our Institute, the radiotherapy techniques that currently require anaesthesia are successfully applied in brachytherapy, intraoperative radiotherapy and in paediatric oncology. General anaesthesia is rarely applied for adults undergoing fractionated course of radiation therapy with the exception of unco-operative patients [3]. We have performed 739 anaesthesia procedures in radiotherapy patients, and felt it would be useful to critically review these cases.

Materials and methods

The Department of Anaesthesia and Intensive Care provides anaesthesia on a daily basis for Surgical Oncology Department, Brachytherapy Department and Radiotherapy Department, all part of the Centre of Oncology – MCS Institute in Gliwice, Poland. Anaesthesia is provided by the attending qualified anaesthetist and certified registered anaesthetic nurse, and an aesthesia resident when present. The records of patients who required anaesthesia for their radiation therapy between January 2000 and September 2005 were retrieved and reviewed by an anaesthesiologist and a radiation oncologist. From each medical record, we abstracted demographic data, type and localisation of neoplasm , radiotherapy data, type of anaesthesia and anaesthesia – related complications. Post-anaesthesia outcome analysis covered the period of 24 hours after the procedure.

The treatment procedures were performed with the ethical standards, approved by the institutional committee when needed and with the Helsinki Declaration.

Results

From January 2000 through September 2005, 739 anaesthesia procedures were performed: 267 in children, 321 in brachytherapy patients, and 151 as a part of intraoperative radiotherapy.

Children. In children requiring external beam radiotherapy (EBRT), anaesthesia was the treatment of choice in very young patients or when educational techniques accompanied by play therapy failed. In our analysis we performed 267 sedative anaesthetics in 16 children ranging in age from 2 – 8 years (median 4.6 years). The patient population contained 9 (56%) females and 7 (44%) males. Diagnoses included: neuroblastoma spatii retroperitonealis in 5 (31%) children, primary CNS tumour in 4 (25%), nephroblastoma renis in 3 (19%), and single cases of gangliorhabdosarcoma retroperinealis, LGM, LMA and LLA. The total number of external beam treatments per course of therapy ranged from 5 to 30 (median 16). All children were immobilized in thermoplastic casts and treated once daily Monday to Friday, with photon energy on a linear accelerator.

In order to provide anaesthesia outside the Anaesthesiology Department, special mobile anaesthesia workstation was arranged. It is equipped with cardiomonitor, pulse oximeter, source of oxygen, instrument for suction and all first aid devices as well as emergency and resuscitation drugs.

The children came every day of treatment from a paediatric hospital to the Radiotherapy Department in Centre of Oncology, usually accompanied by their parents and medical team. A central venous catheter - if not inserted earlier for chemotherapy - was placed to facilitate the radiotherapeutical procedure. Children were not given anything orally for a minimum of 6 hours prior to the procedure.

The attending anaesthetist evaluated the patient and formulated an anaesthetic approach based on clinical examination, current symptoms, and underlying diagnosis. For one patient, when possible, the same method of anaesthesia was employed for the whole course of radiotherapy as well as for cast formation and computed tomography for treatment planning. All children presenting for EBRT were given midazolam and atropine intravenously (iv), next either thiopental iv (216 procedures) or ketamine iv (51 procedures) was administrated until the eyelash reflex ceased. Supplemental O2 was delivered via nasal cannula to all children during procedure. The mean thiopental, ketamine and midazolam doses (± SD) employed were 83 ± 37 mg, 23 ± 20 mg and 1,3 ± 0,5 mg respectively. Parasympaticolytics were given in 166 procedures with average amount of drug 0,1 ± 0,08 mg. Neither skeletal muscle relaxants nor propofol was used in our patients.

Visual monitoring method for children receiving EBRT under aesthesia was direct observation via video cameras only. Cardiopulmonary function was assessed via ECG, blood pressure device and pulse oximeter. Children were recovered in the recovery room in the Department of Anaesthesia and Intensive Care being discharged was when complete recovery was noted clinically by the attending anaesthesiologist.

There were no serious complications of 267 anaesthesia procedures in children. In three cases the treatment was interrupted due to limb movement and deeper sedation with a supplemental dose of drugs was given. In one child it appeared that the drug was administrated partially out of the venous access (the needle dislocated from the venous port). For the other two children the initial doses of sedation drugs appeared as not sufficient to keep the patients calm.

Brachytherapy. Between January 2000 and September 2005, 284 patients underwent brachytherapy under various types of anaesthesia. There were 234 (82%) males with median age of 64 years and 50 (16%) females with median age of 56 years. The majority of patients (197) required one sedation per treatment. In the rest of the group of patients the repeated radiation required repeated anaesthesia so the total number of sedation procedures was 321. All patients were evaluated in a multidisciplinary oncology team and treated in Brachytherapy Department in Center of Oncology in Gliwice, Poland. Radiation was delivered by a Nucletron remote afterloading unit with a 10 Ci ^{192}Ir source. The initial brachytherapy plan included type of applicator, number of needles or catheters and way of insertion e.c. through skin or intraabdominally. Anaesthesia was employed for an applicator location or needle placement and first HDR treatment when possible. Further fractions were given under oral medications to reduce the pain except the cases where another sedation and needle placement were required. The type of anaesthesia (general or local) depended mainly on treated topographical area and the choice of the attending anaesthetist. In total, anaesthesiologist was employed in 321 brachytherapy procedures and covered spinal block in 190 cases, general anaesthesia in 115 cases, and deep sedation in 16 cases. Spinal block was used for pelvic brachytherapy (recto – anal cancers and perineal tumours). General anaesthesia was applied in 91 head and neck cancer cases, 9 pancreas cancers, 6 breast cancer cases, and 4 retroperitoneal sarcomas. Head and neck cancer patients were mainly qualified for endotracheal nasal intubation. In 4 patients temporary tracheostomy was present and in one patient the traditional method of tracheal intubation was performed. In 16 patients qualified for deep sedation, 12 patients underwent brachytherapy of the lung, 2 patients – of the lip, 1 - cheek brachytherapy, and 1 - breast brachytherapy. The choice of a muscle relaxing agent was left to the attending anaesthetist but it was always administered in general anaesthesia.

Propofol, etomidate or thiopental were used for induction of general anaesthesia, following by required doses of fentanyl. For inhalation maintenance a mixture of nitrous oxide and oxygen with sevoflurane was used. The use of skeletal muscle relaxants was left to the attending anaesthetist's discretion.

Spinal block was always preceded with premedication given one hour before the procedure and consisting of 7.5 mg of midazolam orally and 500 cc infusion of crystalloids. The patient was placed in a sitting position. Lumbar area was cleaned and anaesthetized with 1 cc of 1% lidocaine. After 5 minutes spinal block was performed with 0,5% hyperbaric bupivacaine and fentanyl. Immediately after the injection the patient was placed in lithotomy position.

Deep sedation was performed with midazolam and fentanyl, and additional thiopental or propofol when needed.

Due to radioprotection laws, medical and technical staff must leave the shielding room when radiation is on. That applies to anaesthetic team as well. The attending anaesthesiologist observed the patient from control room via monitors and video camera system. ECG, blood pressure, O2 saturation (pO2), respiratory pressure, tidal volume, fraction of inspired O2 (FiO2), respiratory frequent and end tidal CO2 were continuously monitored during the procedure. Usually the patients stayed in the shielding room for a 10 – 20 minute treatment. After the treatment all patients remained in the recovery room in the Department of Anaesthesiology and Intensive Care until they recovered from anaesthetic.

During 321 brachytherapy procedures we did not observe any serious complications related to anaesthesia. In one patient with head and neck cancer after external beam radiotherapy, endotracheal intubation via mouth failed so immediate tracheotomy was performed.

IORT. Intraoperative Radiotherapy (IORT) was performed in 151 breast cancer patients as a part of a treatment protocol that includes initial breast conserving surgery followed by whole breast radiotherapy and / or chemotherapy and hormonal treatment where applicable. All surgeries were performed in the Department of Oncological Surgery in the Centre of Oncology – Institute in Gliwice. Anaesthesia was employed for surgical procedure and extended for radiation treatment. Each patient underwent wide local excision and axillary lymph nodes dissection, and then the appropriate applicator was placed in the tumor bed and attached to the radiation emitter. The technique employs a miniature electron-beam X-ray source that delivers soft X-rays within the tumour bed in breast. Four methods of anaesthesia were administrated: Total Intra Venous Anaesthesia (TIVA) with propofol and remifentanyl in 25 patients, propofol infusion with fentanyl bolus in 41 patients, iv thiopental in 73 patients and iv etomidate in 12 patients. In the last 85 cases the anaesthesia was maintained by iv fentanyl and inhalational sevoflurane in N2O2 / O2. The choice of a muscle relaxant was left to the anaesthetist except in patients undergoing TIVA, where iv atracurium was administered as a part of the procedure. Before starting the irradiation the attending anaesthetist checked the breathing circuit, intravenous lines and monitoring devices and then, after anaesthetic medications had been given, all staff left the operating room. The patient was observed through a portable lead glass window and monitored via set of devices covering: ECG, non-invasive blood pressure, SpO2, respiratory pressure, end-tidal CO2, FiO2, respiratory frequency and end-tidal CO2. IORT extended surgical procedure and anaesthesia for about 10 to 30 minutes. After the surgery all patients were transferred to the recovery room of the Department of Anaesthesiology and Intensive Care until complete recovery was confirmed by the attending anaesthesiologist.

In 151 patients undergoing intra-operative radiotherapy, anaesthesia proceeded without serious complications.

Discussion

Modern radiotherapy is based on team work and an anaesthetist plays an increasingly important role in the treatment. Sophisticated techniques of irradiation and tumor location reduce normal tissue margins to a minimum but also require almost ideal patient immobilization and significantly prolong the irradiation time [4]. The potential consequences of inadequate immobilization have been reported in the literature [5]. There are certain groups of patients referred to a Radiotherapy Department that are not able to stay still throughout the whole irradiation. This applies to unco-operative patients (e.c. mentally disabled) and very young children. Such patients rarely do well with sedation and often require general anaesthesia [6–9]. Other group of patients requiring an anaesthetist for their treatment are those referred for special techniques in radiotherapy such as brachytherapy (mostly interstitial) or intraoperative irradiation. During both techniques an anaesthetist helps the patient cope with the stress and pain. For brachytherapy application an anaesthetist may use general or regional anaesthesia [2, 10, 11]. The intra-operative irradiation is part of the surgical procedure so patients stay under general anaesthesia throughout [12, 13].

Many local attempts have been made to develop institutional protocols and guidelines for anaesthetists providing sedation or anaesthesia for radiotherapy patients, there are few published articles on the subject. Among the published ones, the majority apply to safe and effective sedation in children. However there are guidelines published by the American Academy of Pediatrics but they refer mainly to single procedures [14]. In the available literature we have found only single reports on the role of anaesthesia in brachytherapy or intra-operative irradiation [2, 15].

The sedation of children for radiation therapy has received greater attention in the medical literature however there are no prospective randomized trials in the setting of anaesthesia for paediatric radiotherapy. Sedation is routinely used in children undergoing non-invasive procedures [7, 9, 16, 17]. Very young patients often require general anaesthesia when they are referred for radiotherapy. Deep sedation with preserved spontaneous breathing may be an alternative to general anaesthesia with intubation and controlled ventilation. Intravenous anaesthesia without endotracheal intubation eliminates the risk of laryngeal trauma from repeated instrumentation [6]. Because patients frequently undergo a series of treatments, they require repeated anaesthesia. Many authors recommend intravenous anaesthesia with propofol during radiation therapy. Propofol is a recently released intravenous anaesthetic with quick onset, short duration, low incidence of nausea and vomiting and rapid metabolism to inactive substances but it may cause significant respiratory depression [6, 8, 16, 17]. The risk of propofol induced depression should always be considered before administration. In our study no propofol – based anaesthesia was performed. According to our experience thiopental is effective and safe agent in all radiotherapy patients, not only with brain tumours when ketamine is contraindicated. Ketamine efficacy, when compared with thiopental, is lower due to higher risk of agitation, disorientation or hallucination and involuntarily movements observed in the patients. The administration of ketamine with midazolam may significantly diminish or even abolish these adverse symptoms. In our group of paediatric patients ketamine was not applied routinely due to the risk of drug related side effects. The choice of a satisfactory anaesthetic for the use outside the operating room depended on anaesthetist's experience, type of procedure, availability of equipment and possibility of monitoring the patient [16, 18, 19]. The most of short lasting intravenous anaesthetic techniques do not require a ventilating machine which may be seen as an advantage over inhaled anaesthesia [20].

Brachytherapy presents the anaesthetist with numerous challenges. In this form of radiotherapy the radioactive sources are placed as close as possible to the tumor or tumor bed. The advantage of brachytherapy is an extremely high dose of radiation received by the tumor / tumor bed while the surrounding healthy tissues are spared. The disadvantage is the way of a source placement. Interstitial and very often intracavitary implantation are potentially very painful and the source or special catheters can remain in situ for several hours or even days [2, 21]. Patients vary from highly distressed young adults to the elderly with co-morbidities usually precluding surgery. Treatment in isolated rooms reduces radiation exposure to staff, but makes the monitoring difficult, so the analgesic technique should involve minimum risk to the patient. There is very little published evidence on specific analgesic techniques in brachytherapy. The technique of anaesthesia usually depends on a treated anatomical region. General anaesthesia is a common method in interstitial treatment and usually is restricted to head and neck, thoracic and abdominal regions. In head and neck cancer patients the difficulties with ventilation and endotracheal intubation are observed. This is due to past surgery and / or external beam treatment that may change anatomical proportions in the upper respiratory tract or direct tumor invasion on the airways [22–24]. In our material study we noted one case of impossible endotracheal intubation so immediate tracheotomy was done. In 4 patients temporary tracheotomy was performed prior to brachyterapy. Epidural or spinal anaesthesia is a useful and safe method for pelvic brachytherapy. The advantage of these methods is low risk of cardiopulmonary complications. The patient, left alone in shielded room during radiation exposure, is conscious and artificial ventilation and additional doses of drugs are not necessary [11, 25, 26]. For patients with catheters left in situ for a few days the anaesthetist offers appropriate systemic analgesics and regional blocks to provide safe and effective pain relief. The anaesthetist cooperating with the brachytherapy team must know the range of brachytherapy treatments, predict dangerous complications as well consider potential influence of brachytherapy procedure on anaesthesia drugs intake. In cases when difficult ventilation or tracheal intubation can be predicted it is necessary to prepare adequate equipment for immediate tracheotomy. From our experience it has been noted that better and safer tracheal intubation is performed in spontaneously ventilated patients so muscle relaxants should be abandoned.

In our Institute intraoperative radiotherapy in breast cancer patients is performed in the operating theatre immediately after the surgical procedure. There is no need to transport the patient to a shielding room (soft X-ray beam) however the addition of radiotherapy extends the total time of anaesthesia by 10 to 30 minutes. When we started intraoperative irradiation no guidelines for anaesthetists were available. Thus four methods of anaesthesia have been used. The results of anaesthesia in these groups have been described in detail previously [13]. Summarizing the study we concluded that all four methods of anaesthesia are equally efficient and safe, and the choice of particular technique is left to the attending physician. The only restriction is for older patients in which propofol dose should be reduced.

The gold standard of anaesthetic care is never leave the patient unattended, even for a short period of time unless replaced by an appropriate professional. From the other side, due to radioprotection laws an exemption must be made for the period when the radiation is on. Historically, no direct access to the patient prohibited any anaesthesia procedure. At present, the lack of direct observation of the patients represents a real challenge for modern anaesthesia and may be very stressful, especially for inexperienced doctors. An anaesthetist has to control the vitals relaying on a set of monitors. However the number of monitors employed by anaesthetists has proliferated in recent years, they must not substitute for personal attention of a skilled anaesthetist [27]. The anaesthetist is responsible for the anaesthetized patient's safety also when anaesthesia for radiation therapy is a necessary addition, but cannot be dangerous.

During intraoperative radiotherapy the patient is supervised through a portable lead glass window, in brachytherapy and external beam irradiation only via video cameras. In case of emergency the treatment is stopped to allow direct access to the patient. In other medical centres leaden gowns for whole team are recommended [12].

In our Institute brachytherapy is performed in specially designed shielded rooms fully equipped and served as an operating theatre when needed. External beam irradiation is provided in shielded rooms with no anaesthesia equipment and located close to the Anaesthesia Department. These radiation sites are often constructed without consideration for the provision of anaesthesia, thus the absence of medical gases, wall suction, insufficient electrical installation and adequate scavenging capability create a difficult task for the anaesthesia [16, 28]. Outside the shielding room, the anaesthetist usually is left alone in the environment where no one else may understand the complexities of anaesthesia [29]. All these agents may reduce the margin of the patient's safety. Such situations forced us to arrange a special mobile anaesthesia workstation. Initially it was designed for paediatric patients, but presently it allows us to provide anaesthetic care almost for any patient in any place outside the Department. The mobile workstation is the principal and sole anaesthesiological insurance during all anaesthetic procedures for external beam irradiation.

In conclusion, for uncooperative cancer patients (children) and patients requiring interstitial brachytherapy or intraoperative irradiation we have demonstrated the feasibility and safety of any form of anaesthesia applied in our Institute

Remote observation of the anaesthetized patient during radiotherapy did not influence patient's safety. Immediate access to the patient eliminates negative emotions in the anaesthesia team induced by lack of direct contact with the anaesthetized patient.

Our home designed mobile anaesthesia workstation allows us to provide safe and efficient anaesthesia in any place outside the Department of Anaesthesiology.

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References

[1] PANDYA JB, MARTIN JT Improved Remote Cardiorespiratory Monitoring during Radiation Therapy. Anesth Analg 1986; 65: 529–530. doi:10.1213/00000539-198605000-00021

[2] SMITH MD, TODD JG, SYMONDS RP: Analgesia for pelvic brachytherapy. Br J Anaesth 2002; 88: 270–276. doi:10.1093/bja/88.2.270

[3] TSANG RW, SOLOW HL, ANANTHANARAYAN C, HALEY S Daily general anaesthesia for radiotherapy in unco-operative patients: ingredients for successful management. Clin Oncol (R Coll Radiol) 2001; 13: 416–421.

[4] JEREB B, KRISHNASWAMI S, REID A, ALLEN JC Radiation for medulloblastoma adjusted to prevent recurrence to the cribriform plate region. Cancer 1984; 54: 602–604. doi:10.1002/1097-0142(19840801)54:3<602::AID-CNCR2820540336>3.0.CO;2-Y

[5] REMBIELAK A, WOO TC Intensity-modulated radiation therapy for the treatment of pediatric cancer patients. Nat Clin Pract Oncol 2005; 2: 211–217. doi:10.1038/ncponc0139

[6] FORTNEY JT, HALPERIN EC, HERTZ CM, SCHULMAN SR Anesthesia for pediatric external beam radiation therapy. Int J Radiat Oncol 1999; 44: 587. doi:10.1016/S0360-3016(99)00058-9

[7] PORCHE V Anesthetic considerations in radiologic procedures performed outside the operating room. The Cancer Bulletin, The University of Texas, MD Anderson Cancer Center 1995: 9–19.

[8] SEILER G, DE VOL E, KHAFAGA Y Evaluation of the safety and efficacy of repeated sedations for the radiotherapy of young children with cancer: a prospective study of 1033 consecutive sedations. Int J Radiat Oncol 2001; 49: 771. doi:10.1016/S0360-3016(00)01357-2

[9] WOJCIESZEK E, WOJARSKA-TRĘDA E Deep sedation for radiotherapy in children. Anesth Intens Terap 2004; 2: 110–112.

[10] MUELLER A, WALLNER K, CORRIVEAU J, ARTHUS S, GWINN M et al. A reappraisal of local anesthesia for prostate brachytherapy. Radiother Oncol 2003; 67: 309. doi:10.1016/S0167-8140(03)00033-1

[11] WOJCIESZEK E, WOJARSKA-TRĘDA E, KOLOSZA Z Anesthesia for prostate brachytherapy – own experiences. Australas J Cancer 2005; 3: 147–151.

[12] VAIDYA JS, BAUM M, TOBIAS JS, MORGAN S, D'SOUZA D The novel technique of delivering targeted intraoperative radiotherapy (Targit) for early breast cancer. Eur J Surg Oncol 2002; 28: 447. doi:10.1053/ejso.2002.1275

[13] WOJCIESZEK E, WOZNIAKOWSKA W, KOLOSZA Z, OLEJNIK K, WYDMANSKI J et al. Anaesthesia for intraoperative radiotherapy in patients after breast-conserving surgery. Anesth Intens Terap 2006; 38: 21–24.

[14] Guidelines for Monitoring and Management of Pediatric Patients During and After Sedation For Diagnostic and Therapeutic Procedures. Pediatrics 1992; 89: 1110–1115.

[15] PETEREIT DG, SARKARIA JN, CHAPPELL RJ Perioperative morbidity and mortality of high-dose-rate gynecologic brachytherapy. Int J Radiat Oncol 1998; 42: 1025. doi:10.1016/S0360-3016(98)00349-6

[16] KAPLAN R, YANG C Sedation and analgesia in pediatric patients for procedures outside the operating room. Anesth Clin North Amer 2002; 20: 181–194. doi:10.1016/S0889-8537(03)00060-9

[17] MCDOWALL RH, SCHER CS, BARST SM Total intravenous anesthesia for children undergoing brief diagnostic or therapeutic procedures. J Clin Anesth 1995; 7: 273. doi:10.1016/0952-8180(95)00017-C

[18] METRIYAKOOL K Methohexital As Alternative to Propofol for Intravenous Anesthesia in Children Undergoing Daily Radiation Treatment: A Case Report. Anesthesiology 1998; 88: 821–822.

[19] SOYANNWO O, AMANOR-BOADU S, ADENIPEKUN A, SANUSI AA, AKINYEMI OA Ketamine anaesthesia for young

children undergoing radiotherapy. West Afr J Med 2001; 20: 136–139.

[20] LEDEZ KM, PEACHEY GO, AU JW, SNEDDEN W REPETITIVE inhalation endotracheal anaesthesia for cobalt radiotherapy in a child. Can J Anaesth 1996; 43: 835–851. doi:10.1007/BF03013036

[21] REMBIELAK A, BIALAS B, RUTKOWSKI T, LUKASZCZYK B, SLOSAREK K Evaluation of MDR brachytherapy and teletherapy results in patients with advanced cervical cancer. Nowotwory 2000; 50: 353–356.

[22] NAG S, CANO ER, DEMANES DJ, PUTHAWALA AA, VIKRAM B The American Brachytherapy Society recommendations for high-dose-rate brachytherapy for head-and-neck carcinoma. Int J Radiat Oncol 2001; 50: 1190. doi:10.1016/S0360-3016(01)01567-X

[23] NAG S, TIPPIN D, GRECULA J, SCHULLER D Intraoperative high-dose-rate brachytherapy for paranasal sinus tumors. Int J Radiat Oncol 2004; 58: 155. doi:10.1016/S0360-3016(03)01438-X

[24] SUPKIS DEJ, DOUGHERTY TB, NGUYEN DT, CAGLE CK Anesthetic Management of the Patient Undergoing Head and Neck Cancer Surgery. Int Anesthesiol Clin 1998; 36: 21–29. doi:10.1097/00004311-199803630-00005

[25] CASATI A, ALDEGHERI G, VINCIGUERRA F, MARSAN A, FRASCHINI G et al. Randomized comparison between sevoflurane anaesthesia and unilateral spinal anaesthesia in elderly patients undergoing orthopaedic surgery. Eur J Anaesth 2005; 20: 640–646. doi:10.1017/S0265021503001030

[26] SALINAS FV, SUEDA LA, LIU SS Physiology of spinal anaesthesia and practical suggestions for successful spinal anaesthesia. Best Practice & Research Clinical Anaesthesiology 2003; 17: 289. doi:10.1016/S1521-6896(02)00114-3

[27] ZAUDER H Current questions in patient safety: leaving patients unattended. Anesthesia Patient Safety Foundation Newsletter 1988; 3: 9–16.

[28] ROY WL Anaesthetizing children in remote locations: necessary expeditions or anaesthetic misadventures? Can J Anaesth 1996; 43: 764–768. doi:10.1007/BF03013026

[29] MANNINEN PH Anaesthesia outside the operating room. Can J Anaesth 1991; 38: R126–R129. doi:10.1007/BF03008440