An Example of Facilities for Intraoperative Radiotherapy

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(Key words: anesthetic management, intraoperative radiotherapy, intraoperative radiotherapy unit)

Intraoperative radiotherapy (IORT) is now accepted in many institutions[1] as one of the radiotherapies for cancer. This treatment has several advantages over conventional radiotherapies, but offers anesthesiologist some problems[2]. In Fukui Medical School Hospital, a new IORT unit designed by the suggestion of anesthesiologists was opened on January, 1987. Between then and the end of 1989, 29 patients have received IORT. We describe the anesthetic management of these 29 patients who underwent IORT in this IORT unit.

The Facilities of the IORT unit

Fukui Medical School Hospital IORT unit consists of the radiotherapy room and the room where a patient is operated on for radiotherapy (fig. 1), and is located in the Department of Radiotherapy. After the surgical exposure of cancer in the operating room, the patient is transported to the neighboring radiotherapy room and given direct electron beam therapy. The operating room equipped with the standard equipment seen in ordinary operating rooms is separated from the radiotherapy room by a concrete wall of 1.1 meters in thickness. In the operating room, surgery is performed under the cooperation among the surgical team, a radiotherapist, the nursing staff, and two anesthesiologists. The patient with an open wound is moved to the radiotherapy room, and accurately positioned under the linear accelerator. For this purpose, we provided an operating table which could be transported easily and the movement of which can be regulated minutely. In the operating room, we routinely monitor electrocardiograph, noninvasive blood pressure or invasive arterial pressure, end-tidal CO_2, and arterial oxygen saturation with a pulse oximeter. These monitoring equipments and the anesthesia machine are wheeled along with the patient to the radiotherapy room.

The radiotherapy room equipped with a linear accelerator capable of producing 6 to

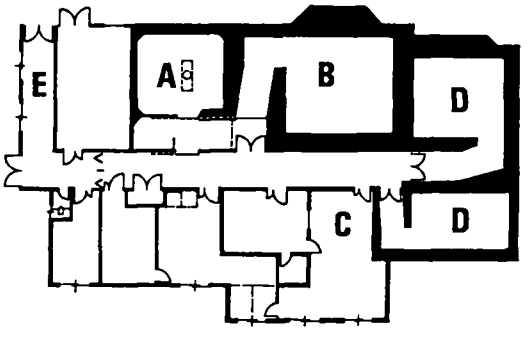

Fig. 1. Schema of the intraoperative radiotherapy unit.

A: operating room, B: radiotherapy room, C: control room, D: subradiotherapy room under construction, E: corridor.

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Table 1. Characteristics of intraoperative radiotherapy patients

Patient No.	Age (yr)	Diagnosis	Duration of anesthesia
1	70	Gallbladder cancer	5°40′
2	46	Pontine glioma	6°15′
3	68	Pancreas cancer	4°00′
4	65	Pancreas cancer	6°30′
5	89	Pancreas cancer	6°50′
6	70	Gallbladder cancer	4°40′
7	60	Pancreas cancer	6°45′
8	57	Pancreas cancer	3°45′
9	37	Pancreas cancer	6°00′
10	58	Pancreas cancer	8°00′
11	66	Pancreas cancer	6°30′
12	46	Pancreas cancer	3°15′
13	80	Pancreas cancer	8°05′
14	78	Pancreas cancer	8°10′
15	82	Pancreas cancer	5°35′
16	70	Pancreas cancer	9°20′
17	68	Gallbladder cancer	13°30′
18	63	Bile duct cancer	10°50′
19	46	Gallbladder cancer	13°40′
20	62	Gallbladder cancer	13°20′
21	68	Pancreas cancer	10°30′
22	71	Pancreas cancer	8°45′
23	69	Bile duct cancer	9°20′
24	33	Gallbladder cancer	10°00′
25	71	Bile duct cancer	6°15′
26	67	Pancreas cancer	9°10′
27	75	Pancreas cancer	8°15′
28	35	Bile duct cancer	14°00′
29	52	Bile duct cancer	11°20′

18 MeV electron beams is surrounded by thick concrete walls, and has a lead-lined door with built-in safety switch. In case an emergency during radiation happens, the radiation from the linear accelerator automatically discontinues. The radiotherapy room is also equipped with two television cameras. One watches the monitoring devices and the anesthesia machine. The other watches the patient and the electron beam columnator. There are also TV monitors and an accelerator control panel in the control room.

The Anesthetic Procedure

Table 1 shows the characteristics of patients undergoing IORT at our institution between 1987 and 1989. They all received laparotomy except for one craniotomy. They were intubated and generally anesthetized with enflurane, nitrous oxide and oxygen in operating room.

During the radiation, the patient was perfectly paralyzed with muscle relaxant to prevent unexpected patient movement, and was mechanically ventilated with a tidal volume of less than 10 $ml \cdot kg^{-1}$ to minimize the movement of upper abdominal tumors caused by ventilation. Anesthesia was maintained with enflurane in oxygen to increase the radiosensitivity of tumor cells[3]. Because nobody except a patient can remain in the radiotherapy room throughout the radiation period, the anesthesiologists must watch the patient from control room by TV monitor.

Radiation exposure at each site lasted about five min, and the duration of radiation was less than 20 min for all the patients. No problems, such as an undesirable change in blood pressure or troubles of endotracheal tube, were encountered. Therefore, it was not necessary to interrupt radiotherapy. There have been no complications attributable to anesthetic management. After completion of the surgical procedure, 16 patients were transferred to the ICU and 13 patients to the wards.

Discussion

The greatest advantage of IORT is that a higher dose of radiation can be applied directly to the surgically exposed tumor, thereby sparing adjacent normal tissues from the path of the beam[4]. In terms of anesthesia, however, IORT has presented various problems[2,5]. The two major problems are as follows: 1) the anesthetized patient with an open wound must be transported during the course of the operation from the operating room to the radiotherapy room, 2) the patient must be left alone in the radiotherapy room during the radiation.

In our institution, the radiotherapy room and the operating room were constructed adjacently according to the suggestion of the anesthesiologists. This is the most favorable design of our IORT unit, in comparison with many other institutions[2,6], where the patient

with an open wound must be transported a long distance because the radiotherapy room is far from the operating room. However, we could not combine the operating room with the radiotherapy room in one room, because our radiotherapy room must be occasionally used for the other operations when the operating room is used for IORT. Consequently, the only remaining problem is that the patient must be transported with the anesthesia machine and the monitoring equipment from one room to the other. Moreover, we prepared the movable operating table and used it as the treatment table for radiation, too.

Because the duration of radiation exposure by linear accelerator is comparatively short, no emergency has been reported during the radiation period[2,5,6]. Undoubtedly, monitoring of the patient's vital signs and visual observation of the patient by the television cannot be spared. Increasing monitoring devices, however, make the transport of the patient more troublesome. Therefore, the integrated monitoring system which can display a large amount of information from the patient is desirable for this procedure.

With the increase of major surgical procedures in the IORT unit, complications such as excessive bleeding or cardiac arrest may increase. In such an emergency, the aid of other anesthesiologists from the main operating room may be delayed because of the geographic distance between the IORT unit and the central operating theater on 3rd floor of our institute. The distance between the two places is about 100 meters through a corridor. Although we keep contact closely between the two places by intercom, this problem remains. In order to cope with this, we intend to install closed circuit television between the IORT unit and the central operating theater.

We conducted anesthesia to patients undergoing IORT in the IORT unit, the design of which incorporated the suggestions of anesthesiologists. Although the problem caused by some distance between the IORT unit and the central operating theater still remains, we have prevented the occurrence of troubles attributable to interdepartmental transfer of patients in other institutions by constructing the radiotherapy room and the operating room adjacently in the IORT unit.

(Received Mar. 9, 1990, accepted for publication Jul. 26, 1990)

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