Staff Exposure During a HDR Endobronchial Brachytherapy Stuck Source Event Requiring Surgical Extraction: A Full-Scale Simulation

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INTRODUCTION

A source stuck inside a patient represents a major emergency in HDR brachytherapy. Canadian nuclear safety regulations (Nuclear Safety and Control Act, NSCA) ask that a Radiation Protection Training Program (RPTP) provides all stakeholders with safety training in regard to their tasks. While nuclear regulatory agencies insist on conducing real-life conditions emergency drills, it is scarcely put into practice. Real-life situations such as the example of the "stuck source" is associated with a high risk for both patient and staff, and a high level of stress while having a low probability of occurrence. We believe this HDR emergency drill is the first of its kind to be conducted and quantified, since the introduction of the Canadian Nuclear Safety Commission (CNSC) requirement.

AIM

As a newly opened institution starting a brachytherapy program, we wanted to simulate an emergency source extraction procedure and design the emergency team response protocol while assessing all resulting staff exposure.

METHOD

Teams were video recorded in an emergency setting during a simulated endobronchial HDR treatment performed with a mannequin. The event was gradually escalated in severity with the regular personnel until a surgical source extraction was simulated by an emergency surgery team. Operators' locations and exposure durations were extracted from video recordings to: 1) measure exposure rates at those locations and 2) estimate total exposure duration for each staff member. Level of preparedness was surveyed at the end of the exercise. Dose measurements were performed with a Fluke Model 451 ion chamber survey meter using conservative measurement parameters with a newly installed source of activity 10 Ci.

RESULTS

13 staff members participated, including workers from and outside the radiation oncology department. Fig.1 shows the staff location during source extraction. Fig.2 shows the patient in the treatment environment.

Table 1 reports the doses for the 9 distinct roles involved. The total time from source emergency inception to extraction was evaluated between 2.5h to 3h, mainly due to preparing the patient for lung surgery, including anesthesia and positioning in lateral decubitus, the latter taking up to 60 min. The surgical extraction was evaluated at 60 min. Estimates of effective doses from measurements performed after the exercise range from 0.2 mSv for the least exposed staff (radiation therapist) to 102.4 mSv for the most exposed staff members (surgeon and assistant).

A post-exercise qualitative questionnaire showed an increase in the feeling of the team preparedness level. All the staff members agreed on the need for simulated exercises in real-life treatment conditions to increase level of confidence in the coordination of the emergency response, and also to have a better understanding of the respective tasks of all staff members.

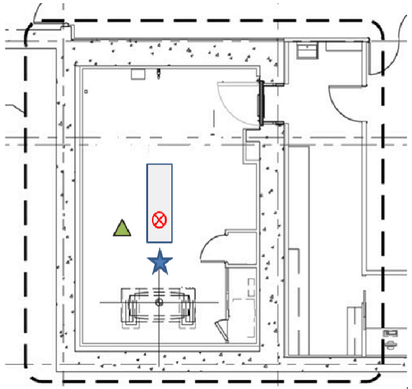

Figure 1 : HDR room layout with indication of staff location: red rounded cross for approximate source location, blue star for anesthesiologist or respiratory therapist and green triangle for surgeon or surgeon assistant

Operators	Cumulated effective dose (mSv)
Surgeon	102.4
Surgeon assistant	102.4
Anesthesiologist	55.5
Respiratory therapist2	38.4
Respiratory therapist1	12.8
Respirologist	12.8
Radiation Oncologist	1.04
Medical physicist	0.8
Radiation Therapist	0.2

Table 1: Cumulated hypothetic dose for staff members during the entire simulation

Figure 2: Photo of the brachytherapy room with mannequin installed in treatment position

CONCLUSIONS

Dose estimates for staff were obtained for an emergency lung HDR simulation. Results are compatible with the feasibility of a surgical extraction without exceeding current regulation in the event of an emergency that aims to prevent fatal or life-threatening radiation effects. Currently this effective dose limit is 500 mSv. This exercise is now included annually in the RPTP. The simulation in real conditions allows an improvement in the staff emergency response. It is highly suggested that each simulation should be specifically adapted to the anatomical site treated with all the patient's life sustaining equipment. While designing the training and with the dose estimates obtained further questions implying ethics, staff exposure justification, and other ALARA principles remain under investigation.

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