Left-sided breast/chest wall irradiation using Deep Inspiration Breath Hold (DIBH) technique to reduce the radiation exposure of the heart

1. Introduction

Breast cancer is the leading cause of cancer and death among women. The majority of patients are long-term survivors and receive radiotherapy [1]. Possible chronic side effects of radiotherapy, up to a decade later, are ischemic heart disease and diffuse myocardial damage associated with radiogenic heart damage [2-4]. In addition to the radiation dose to the heart, the risk of heart damage is influenced by the patient's age, other risk factors, comorbidities, and treatments [4]. Several attempts have been made to reduce the exposure of the heart during radiotherapy [5]. Special irradiation techniques (IGRT, IMRT) can be used, the irradiated volume can be reduced in low-risk cases (partial breast irradiation), and finally efforts can be made to remove the heart from the irradiated volume. An example of the latter is the treatment of the patient in prone position. Only in recent years has respiratory-guided radiation therapy emerged, the essence of which is that irradiation occurs only in the deep inspiratory phase, when the enlarged lung, wedged between the heart and chest wall, removes it from the irradiation fields [5-7].

Respiratory-guided radiation therapy usually requires special equipment. One method requires a spirometer, the other is radiotherapy, detecting infrared signals following movement of the chest wall, gating the radiotherapy. Both methods significantly reduce heart exposure by about one-tenth [6,7]. The introduction of these methods is hampered by their high cost. (In Western Europe, up to 20% of radiotherapy centers use these techniques.) Therefore, Royal Marsden Hospital staff in the UK have developed a protocol for Deep Inhalation Respiratory Retention Radiation Therapy (DIBH) (HeartSpare I Study) [6], and work on its nationwide spread (HeartSpare II Study) [7]. Studying the method in a randomized study (HeartSpare I Study), it was found that the method is acceptable, successful, and reliable for both patients and treatment staff.

In our clinical trial, radiotherapy is expected to be performed according to the DIBH protocol in all cases, but this treatment is compared dosimetrically with the corresponding parameters of conventional radiotherapy, which certainly results in higher cardiac exposure [8,9], furthermore we would like to study the feasibility of the new method.

2. **Study period:** September 2017 – December 2019

1) **Aims:** Incorporating the DIBH technique into everyday practice and comparing it with previous techniques

   Primary endpoint: examination of cardiac exposure during DIBH irradiation in supine position vs. by irradiation according in the optimal position (prone or supine) used at our Department, considering the following dosimetry data:

   a. Mean heart dose (MHD)
   b. V25Gy of the heart
   c. mean dose to the LAD
   d. maximum dose to the LAD

2) Secondary endpoints:

   a. Exposure of other organs at risk (ipsi- and contralateral lung, contralateral breast)
   b. Positioning accuracy during treatment (random and systematic error calculation)
   c. Intrafractional positioning accuracy (random and systematic error)
   d. Duration of planning CT preparation
   e. Duration of irradiation per fraction (positioning and delivering radiotherapy)
   f. Evaluation of the method by the patients (2 times)
   g. Evaluation of the method by radiotherapists (at planning CT preparation and at completion of the treatment)
   h. Evaluation of the percent of the patients eligible for DIBH irradiation (agreement to treatment and capability)

3. **Design:** single arm, non-randomised

4. **Number of patients:** 70

5. **Inclusion criteria:**

   a. Radiation therapy is required for left breast cancer
   b. Informed consent of the patient to participate in the study

6. **Exclusion criteria**

a. Contraindication of radiotherapy
b. Patient is not capable for performing DIBH

7. Study process

a. Informed consent
b. Patient enrollment
c. Planning CT, treatment planning in both DIBH and conventional supine or prone position
d. Irradiation using DIBH technique

8. Detailed protocol

see appendix 1

9. References

1. Clarke M, Collins R, Darby S et al.; Early Breast Cancer Trialists' Collaborative Group (EBCTCG). Effects of radiotherapy and of differences in the extent of surgery for early breast cancer on local recurrence and 15-year survival: an overview of the randomised trials. Lancet. 2005;366:2087-106.
2. McGale P, Darby SC, Hall P et al. Incidence of heart disease in 35,000 women treated with radiotherapy for breast cancer in Denmark and Sweden. Radiother Oncol. 2011;100:167-75.
3. Darby SC, Ewertz M, McGale P, et al. Risk of ischemic heart disease in women after radiotherapy for breast cancer. N Engl J Med 2013;368:987–98.
4. Taylor CW, Kirby AM. Cardiac side-effects from breast cancer radiotherapy. Clin Oncol (R Coll Radiol). 2015;7:621-9.

5. Shah C, Badiyan S, Berry S et al. Cardiac dose sparing and avoidance techniques in breast cancer radiotherapy. Radiother Oncol. 2014;112:9-16.
6. Bartlett FR, Colgan RM, Donovan EM et al. The UK HeartSpare Study (Stage IB): randomised comparison of a voluntary breath-hold technique and prone radiotherapy after breast conserving surgery. Radiother Oncol. 2015;114:66-72.
7. Bartlett FR, Donovan EM, McNair HA et al. The UK HeartSpare Study (Stage II): Multicentre Evaluation of a Voluntary Breath-hold Technique in Patients Receiving Breast Radiotherapy. Clin Oncol (R Coll Radiol). 2017;29:e51-e56.
8. Varga Z, Hideghéty K, Mező T, Nikolényi A, Thurzó L, Kahán Z. Individual positioning: A comparative study of adjuvant breast radiotherapy in the prone versus supine position. Int J Radiat Oncol Biol Phys 2009;75:94-100.
9. Varga Z, Cserháti A, Rárosi F et al. Individualized positioning for maximum heart protection during breast irradiation. Acta Oncol. 2014;53:58-64.