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Original article

Dosimetric comparison of moderate deep inspiration breath-hold and free-breathing intensity-modulated radiotherapy for left-sided breast cancer



Comparaison dosimétrique de l'inspiration modérément profonde en apnée et de la respiration libre pour la radiothérapie avec modulation d'intensité du cancer du sein gauche

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ABSTRACT

Purpose. – This study determined the dosimetric comparison of moderate deep inspiration breath-hold using active breathing control and free-breathing intensity-modulated radiotherapy (IMRT) after breast-conserving surgery for left-sided breast cancer.

Patients and methods. – Thirty-one patients were enrolled. One free breathe and two moderate deep inspiration breath-hold images were obtained. A field-in-field-IMRT free-breathing plan and two field-in-field-IMRT moderate deep inspiration breath-holding plans were compared in the dosimetry to target volume coverage of the glandular breast tissue and organs at risks for each patient.

Results. – The breath-holding time under moderate deep inspiration extended significantly after breathing training ($P < 0.05$). There was no significant difference between the free-breathing and moderate deep inspiration breath-holding in the target volume coverage. The volume of the ipsilateral lung in the free-breathing technique were significantly smaller than the moderate deep inspiration breath-holding techniques ($P < 0.05$); however, there was no significant difference between the two moderate deep inspiration breath-holding plans. There were no significant differences in target volume coverage between the three plans for the field-in-field-IMRT (all $P > 0.05$). The dose to ipsilateral lung, coronary artery and heart in the field-in-field-IMRT were significantly lower for the free-breathing plan than for the two moderate deep inspiration breath-holding plans (all $P < 0.05$); however, there was no significant difference between the two moderate deep inspiration breath-holding plans.

Conclusion. – The whole-breast field-in-field-IMRT under moderate deep inspiration breath-hold with active breathing control after breast-conserving surgery in left-sided breast cancer can reduce the irradiation volume and dose to organs at risks. There are no significant differences between various moderate deep inspiration breath-holding states in the dosimetry of irradiation to the field-in-field-IMRT target volume coverage and organs at risks.

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R É S U M É

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Objectif de l'étude. – L'objectif de cette étude était la comparaison dosimétrique de l'inspiration modérément profonde en utilisant le contrôle actif de la respiration et la respiration libre pour la radiothérapie conformationnelle avec modulation d'intensité (RCMI) après chirurgie mammaire conservatrice du cancer du sein gauche.

Patients et méthodes. – Trente et une patientes ont participé à cette étude. Il a été obtenu une image de respiration libre et deux en inspiration modérément profonde. Des plans de RCMI, un en respiration libre, deux en inspiration modérément profonde avec la technique du champ dans le champ ont été réalisés pour comparer la distribution de dose dans le volume cible du tissu glandulaire du sein et les organes à risques pour chaque patiente.

Résultats. – La durée de l'apnée a été évidemment allongée par l'inspiration modérément profonde ($p < 0,05$). Il n'y avait pas de différence significative entre la respiration libre et l'inspiration modérément profonde avec la technique du champ dans le champ pour la couverture du volume cible. Le volume du poumon homolatéral irradié était évidemment plus petit avec la respiration libre qu'avec la respiration modérément profonde ($p < 0,05$); pourtant, il n'y avait pas de grande différence entre les deux plans en inspiration modérément profonde avec la technique du champ dans le champ. Il n'y avait pas non plus de différence significative pour couverture du volume cible entre les plans de RCMI avec la technique du champ dans le champ, celui en respiration libre et les deux en inspiration modérément profonde ($p > 0,05$). Les doses dans le poumon homolatéral, l'artère coronaire et le cœur étaient évidemment plus faibles avec la technique de RCMI champ dans le champ en respiration libre qu'avec les deux plans en inspiration modérément profonde ($p < 0,05$); de même, il n'y avait pas de différence significative entre les deux plans en inspiration modérément profonde.

Conclusion. – La RCMI du sein avec la technique du champ dans le champ en inspiration modérément profonde et le contrôle actif de la respiration après chirurgie conservatrice du sein gauche permettent de réduire le volume irradié et la dose délivrée aux organes à risque. Il n'y avait pas de différence significative entre les plans en inspiration modérément profonde en RCMI avec la technique du champ dans le champ pour la couverture du volume cible et les organes à risque.

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1. Introduction

Radiothérapie improved survival in breast cancer after breast conservation surgery and mastectomy [1–4]. However, cardiovascular disease and lung cancer mortality rates had significantly increased after radiotherapy with more than 15 years follow-up [5]. Recent studies have indicated that the reduction in breast cancer mortality is offset by the increased risk in cardiac mortality due to breast irradiation [6,7]. The risks due to breast irradiation are further exacerbated when radiotherapy is used as an adjuvant treatment with biological therapy, such as trastuzumab and anthracycline-based chemotherapy [8,9]. Further, it has shown that increased cardiac radiation exposure from the deep edge of the tangential beams, which are normally used in left-sided breast cancer, is associated with increased risks of heart disease and cardiac mortality [1].

Development of intensity-modulated radiotherapy (IMRT) is regarded as a milestone of radiotherapy in the 21st century. The clinical target volume of glandular breast tissue is the target volume referred to for radiation therapy after breast-conserving surgery. IMRT not only improves dose homogeneity in the target volume coverage, but also reduces the radiation dose to the organs at risks, including the heart and lungs [10,11]. The target volume movement is an important factor affecting the dose–volume parameters of whole-breast IMRT. After online correction of the set-up errors, the target volume movement due to this error is reduced significantly; however, the impact of target volume movement caused by respiratory motion on the dose–volume parameters is a major area of interest in current relevant studies. Although the impact of respiratory motion on target volume movement is milder during quiet breathing, there is no consistent agreement on changes in dose–volume parameters of the target volume coverage and organs at risks due to movements caused by respiratory motion, which inhibits the widespread development of IMRT in the treatment of breast cancer.

It has been reported that the active breathing control-IMRT technique could further reduce the dosimetric difference in the target volume coverage caused by the respiratory motion and reduce target movement under 5 mm [12,13]. The active breathing control technique currently used in radiotherapy can decrease the uncertainties caused by respiratory motion [14–16]. In addition, studies have shown that deep inspiration results in an increased distance between the heart and the left anterior chest wall [17].

Therefore, we applied the active breathing control technique to 31 patients with left-side breast cancer who underwent breast-conserving surgery between January 2008 and July 2011. We compared the dosimetric differences of forward-planned whole-breast field-in-field-IMRT between the free breath state and the moderate deep inspiration breath-hold state, and between different moderate deep inspiration breath-hold states to further clarify the value of the breathing control technique during radiotherapy for breast cancer.

2. Patients and methods

2.1. Patients

Patients who underwent breast-conserving surgery for early-stage left breast cancer at Sun Yat-Sen University Cancer Center were recruited according to the following inclusion criteria:

- female patient aged 18 years or older;
- pathologically-confirmed breast cancer;
- axillary lymph node dissection or sentinel lymph node biopsy-confirmed pathology-negative lymph nodes;
- stage I or II (pT1N0M0, pT2N0M0) according to the 2009 7th edition of the American Joint Committee on Cancer (AJCC) TNM staging;

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