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Can we obtain planning goals for conformal techniques in neoadjuvant and adjuvant radiochemotherapy for gastric cancer patients?

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ABSTRACT

Aim: The purpose of this study was to compare conformal radiotherapy techniques used in the treatment of gastric cancer patients. The study is dedicated to radiotherapy centres that have not introduced dynamic techniques in clinical practice.
Background: The implementation of multi-field technique can minimise the toxicity of treatment and improve dose distribution homogeneity in the target volume with simultaneous protection of organs at risk (OaRs). Treatment plan should be personalised for each patient by taking into account the planning target volume and anatomical conditions of the individual patient.
Materials and methods: For each patient, four different three dimensional conformal plans were compared: 2-field plan, 3-field plan, non-coplanar 3-field plan and non-coplanar 4-field plan. Dose distributions in a volume of 107% of the reference dose, and OaRs such as the liver, kidneys, intestines, spinal cord, and heart were analysed.
Results: The mean volume of the patient body covered using the isodose of 107% was 3004.73 cm^3, 1454.28 cm^3, 1426.62 cm^3, 889.14 cm^3 for the 2-field, 3-field, non-coplanar 3-field and non-coplanar 4-field techniques, respectively. For all plans the minimum dose in the PTV volume was at least 95% of the reference dose. The QUANTEC protocol was used to investigate doses in OaRs.
Conclusions: Comparison of 3D conformal radiotherapy techniques in gastric cancer patients indicates that none of the plans can fulfil simultaneously all of the criteria of the tolerance dose in the organs at risk. The implementation of the multi-field technique can minimise

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the toxicity of treatment and improve dose distribution homogeneity in the target volume with additional protection of organs at risk (OaRs).

1. Background

Gastric cancer is the third most frequent cause of death from cancer worldwide, with 723,027 deaths registered in 2012.[1] The primary treatment modality of gastric cancer is surgery.[16] This treatment strategy is frequently employed in the early stage of cancer. Radical operation (R0) can be performed in approximately 50% of patients because of the diagnosis of cancer in the locally advanced or dispersal stage. Since the INT-0116 study was published, the standard for $pT_{2\text{-}4}$ $N_{0\text{-}3}$ or $pT_1N_{1\text{-}3}$ gastric cancer is postoperative radiochemotherapy.[2,6] At some oncology centres, R1 surgical resection is also an indication for postoperative radiochemotherapy.[3] Implementation of this scheme enhances both local cure and the 5-year survival by approximately 15% compared with independent surgery treatment.

Initially, at many radiotherapy departments, a recommended two dimension (2D) technique using two opposing fields was applied for gastric cancer treatment. The constraint of 2D radiotherapy for the abdominal area is the close localisation of organs at risk such as the kidneys, liver, intestines and spinal cord. Consequently, this radiotherapy induced high hematologic toxicity of the digestive system and was completed earlier than planned in 17% of patients.[4] With recent advances in technology, computer dose distribution calculations have been shown to allow the introduction of three dimension (3D) conformal techniques (conformal radiotherapy; CRT) in common applications. These techniques turn out to be more effective in achieving high, homogeneous dose distribution in the target volume with simultaneous sparing of normal tissues. In the 3D conformal technique the shape of the planning target volume (PTV), mutual localisation of the target volume and organs at risk are all considered.[5] Dose distribution in the 3D technique allows the acquisition of more information than that in 2D planning. 3D planning exposes the local maximum of the dose distribution (hot spots) or allows localised regions of PTV that are not covered by the reference dose (cold spots).

The application of two opposing fields in gastric cancer radiotherapy, even in 3D conformal radiotherapy, promotes a high risk of radiation complications of the 3rd and 4th degrees.[2] The implementation of multi-field technique can considerably minimise the toxicity of treatment and improve dose distribution homogeneity in the target volume with simultaneous protection of organs at risk, such as the liver, kidneys, spinal cord and intestines. Selection of the appropriate three dimension (3D) conformal technique should be personalised to each patient by taking into account the target volume PTV and anatomical conditions of the individual patient.[19]

The idea of conformal radiotherapy is not new; however, recently, 3D treatment planning has allowed the introduction of this technique in clinical practice. Currently, in many countries, 3D conformal techniques for gastric cancer radiotherapy are commonly used, where the shape of the treatment fields fits the PTV, which is defined based on CT imaging (and other helpful imaging modalities, such as PET-CT or MRI).[8] At our department, postoperative radiochemotherapy has been the standard treatment for 15 years, and neoadjuvant radiochemotherapy has been the subject of research for 10 years.[7]

2. Aim

The aim of this study was to compare the 3D conformal techniques used in gastric cancer patients who qualified for adjuvant or neoadjuvant radiochemotherapy. The study is dedicated to radiotherapy centres that have not introduced dynamic techniques in clinical practice.

3. Material and methods

A retrospective analysis was performed on 20 gastric patients. For each patient, four different plans were performed. 3D techniques of two opposing fields (AP-PA) (2F), three coplanar fields (3F), three non-coplanar fields (3nF) and four non-coplanar fields (4nF) were used (Fig. 1a–d). Figures show the example of the beam orientation for the radiotherapy plans. However, the number of beams was constant but the beam angles were personalised for each patient because of anatomy of the patient and localisation of the target. Patients were stabilised using thermoplastic masks that covered the chest and abdominal regions. For treatment planning, computed tomography (CT) data sets with a 3-mm slice thickness were acquired. During the study, contrast agent was applied to the patient's vein for better visualisation of blood vessels on CT images and to facilitate contouring of the nodal regions. Additionally, each preoperative patient had to drink 500 ml of water to fill the stomach for imaging of the tumour. The volume of this liquid was equivalent to a light breakfast. Data sets were imported to the treatment planning system (TPS), where the target volumes (gross tumour volume – GTV, clinical target volume – CTV, planning target volume – PTV) and organs at risk (spinal cord, kidneys, liver, intestines, lungs, and heart) were contoured. The GTV was delineated based on the CT and gastroscopy results. The CTV volume includes the postoperative stomach lodge or stomach and regional lymph nodes (celiac trunk, splenic, pancreatic duodenal, pancreatic, portal vein, para-aortic, para-oesophageal and perigastric nodes). The PTV volume was defined as a 1-cm margin around the CTV. The planned total dose was 45 Gy in 25 fractions.

The main purpose throughout planning of the dose distribution was to cover the entire PTV using 95% of reference