A METHOD FOR PLANNING TREATMENT OF INTRAOPERATIVE RADIOTHERAPY — USE OF INTRAOPERATIVE ULTRASONOGRAPHIC DIAGNOSIS

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Abstract Intraoperative ultrasonography (IOUS) is useful in planning treatment by intraoperative radiotherapy (IORT), since it clearly visualizes the contour of the tumor or the target volume. The depth of the tumor or the target volume can be measured by IOUS; therefore the optimum energy of the electron beam which contains them in 90% of the maximum dose of the isodose curve can be selected. The dose of radiation to the adjacent structures should be kept to a minimum. By the use of a treatment planning unit (Theraplan), the contours of the organ on the ultrasonography could be traced with a light pen, and the isodose curve of several electron energies could be demonstrated on the input image. Since this procedure required only a few minutes, the real time treatment by IORT could be planned.

Key words: Intraoperative radiotherapy, Intraoperative ultrasonography, Intraoperative radiotherapy treatment planning

INTRODUCTION

In intraoperative radiotherapy (IORT), the target area of the irradiation can be observed directly during surgery. The dimensions of the target area can be measured but the depth of the target cannot be determined. The size of the tumor or target may be estimated by X-CT before the operation, but the surgical procedure easily causes changes in it. The dose of radiation to the target area should be 90% of the maximum dose, and the dose received by the adjacent normal structures should be kept to a minimum. The selection of the optimum energy of the electron beam is an important step in IORT.

Intraoperative ultrasonography (IOUS) has been applied to liver cancer and other cancers, and its value is established. The scale in the ultrasonographic image is quite accurate, therefore the depth of the tumor or target area can be estimated accurately from the images. The usefulness of IOUS as an aid to intraoperative electron beam therapy has been reported. We use IOUS in IORT routinely. Here we report the use of IOUS for further planning of treatment of pancreatic tumors by IORT.

MATERIALS AND METHODS

IOUS apparatus: A specially designed intraoperative US lineararray probe (Aloka SSD 30) which was operated at 7.5 MHZ was used. Various ultrasonography are obtained by moving the probe at the surface of the tumor or target area to visualize the best and most useful images (Fig. 1). Sometimes a small water bag was used to obtain...
better penetration of the ultrasound. This procedure was done carefully to avoid any distortion of the tumor contour by pressure. The IOUS could be performed at any time during the operation, and as shown in Fig 2-a, the contour of the tumor was clearly visualized, and the depth of the tumor could be defined. Fig 3-a is the image after removal of the pancreatic tumor. The center of the target area was the origin of the celiac artery from abdominal aorta. In Fig. 3, the depth of the aorta and the vertebra are easily recognized.

TREATMENT PLANNING

Since the scale factor on an ultrasonography is 0.8, direct overlapping of the isodose curve of a given electron beam energy was not possible. Therefore redrawing the contour of the tumor and the adjacent structures to the normal scale was necessary. A treatment planning system (Theraplan, Theratronics Int. Ltd.) facilitated the direct input of the contour of the critical structures and the target volume in the ultrasonography by using a light pen. The accuracy of the input figures was dependent on the sharpness of the US image and skill in handling the light pen. The scale could be corrected, and the isodose curve of the electron beam could be demonstrated on the traced figure. The isodose curves of several electron energies can be demonstrated serially. The energy could be selected so that the target volume would be included within 90% of the isodose curve. This method has been applied to IOUS of pancreatic tumors of 10 patients. The procedure can be performed within a few minutes, therefore it could be used to optimize the treatment.

RESULTS AND DISCUSSION

Fig 2-b shows the isodose curve for planning treatment of a pancreatic tumor. The tumor area was included within 90% of the isodose level at 13 MeV, an area 6 cm in diameter. Fig 3-b shows the same planning procedure after removal of the tumor. The upper surface of the abdominal aorta was included within 90% of the isodose curve. At an electron energy of 6 MeV, the surface of the vertebra received less than 10% of the maximum dose. The decision regarding the target volume to be irradiated after removal of the pancreatic tumor was difficult. Microscopic invasion of the tumor to the lymph
nodes in the paraaortic region would be suspected. The target volume should include the paraaortic region. In conclusion, IOUS is simple procedure and gives us the necessary information for the planning the treatment of IORT. The use of a treatment planning system which facilitates quick demonstration of the isodose curves on the traced image was also helpful.

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Fig. 3. Intraoperative ultrasonography and isodose curve of the target area after removal of the pancreatic tumor.

a: Ultrasonography and explanation of the image.

b: Isodose curve of 6 MeV, 6 cm in diameter, of the electron beam. Surface correction was made. The upper part of the aorta was included in the 90% isodose level.

REFERENCES


要旨：術中照射での治療計画として、腫瘍又は標的部位の範囲を正確に把握するために、術中超音波診断画像が有用であることが判った。特に深さ方向を計測することによって、腫瘍又は標的部位が電子線の90%線量範囲に入るように、電子線エネルギーを選択することが出来る。周辺正常組織に対する照射量を最小とすることが必要であり、これを可能とするステップの一つである。計画に用いたTheraplanは、超音波画像をライトペンで入力することにより、いくつかの電子線エネルギーのisodose curveを入力画像上に示すことが可能であり、且つ、画像が得られてから数分間程度で作業を進めることができる。術中照射治療計画の即時化がおこなわれるのでは、有用であることが判明した。