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Stereotactic radiotherapy of malignant tumors of the liver with golden markers application.

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Abstract

The implantation of the gold markers into liver tumors has been performed in Cancer Center Institute of Oncology in Gliwice Branch since September 2010

This method allows to perform image guided stereotactic radiotherapy, easier localization of tumor in computer tomography and precise positioning of the patient during the treatment. It allows to minimalise irradiated volumes what is connected with possibility of margins reduce and in consequence better protection of normal tissues or frequency of adverse effects. Moreover such method probably allows to increase the total dose in target volume without risk of higher incidence of side effects occuring. We didn`t observe any complications connected with performed procedure among treated patients.

Key words:

liver cancer, liver metastatic disease, IGRT, gold markers, radiotherapy

Since May 2009 we have started implantation of the gold markers „Gold Anchor ^{TM}" into prostate gland among patients with prostate cancer irradiated in Department of Radiotherapy Cancer Center MSC Memorial Hospital Gliwice Branch [1]. In this period we have implanted markers in over three hundred of patients. Good tolerance and lack of adverse effects encourage to wider using in another localizations such lung, liver, pancreas or in gynecological tumors. The aim of this method is a precise verification of localization of the structures with high move ability and to give an opportunity to appropriate positioning of the patient during treatment seance.

As a first Department in Poland we implanted such markers into malignat liver tumors in September 2010. Currently the stereotactic radiosurgery of metastatic or primary malignant liver tumors becomes more and more popular [2, 3, 4, 5, 6, 7, 8, 9, 10]. The previous failures and reluctance to irradiation in such localisation were conected with lack of possibilities with precise delivering of high radiation dose into small volumes. The result of this was insufficient protection of healthy part of the liver. For many years the role of radiotherapy in such localisations was restricted only to palliative treatment of multifocal liver metastatic disease and radical treatment was reserved mainly for surgeons.

There are some alternative methods of paliative treatment in such localization like percutaneus ethanol injection [11, 12, 13, 14], termoablation [15, 16, 17, 18, 19], arterial chemoembolization [20, 21, 22], arterial targeted chemiotherapy [23, 24, 25, 26], cryotherapy [27], intraoperative radiotherapy [28], radioisotopes [29, 30, 31].

The qualification criterias to fractinated stereotactic radiotherapy (FSRT) are: diameter of laesion up to 6 cm [9], no more than 3 leasions, good performance status (Zubrod 0-2), liver enzymes in blood test not higher than 3 times of reference level, proteins level no lower than 6g%, normal level of blood coagulation examination. The total dose of irradiation is 30-36 Gy in 3 fractions per 10-12 Gy with one week gaps [32].

The application of gold anchors gives an opportunity to perform the IGRT (image guided radiotherapy), easier localization of a tumor in CTs for planning of a treatment, and precise positioning of the patient during treatment seance. Moreover the markers are used in CyberKnife tracking system.

There are a lot of IGRT methods. The most common are CBCT, 2D-2D KV [33, 34], X-Ray which are based on kilovoltage rays.Others are ultrasonography [35, 36], In-room MRI or CT on rails [37].

Some of these methods are often used in Gliwice Department of Radiotherapy espetially during irradiation of tumors of men's genitourinary system. Till now these methods weren`t helpful in localisation of liver tumors due to high movement of the liver toward bone structures. The usefulness of CBCT was dissapointed and not useful because of poor quality of images.

Gold markers in liver tumors gives an opportunity to precise localisation of the laesion and higly accurate irradiation. In these localisation the situation is more complicated than among patients with prostate cancer. The reason is the very high movement ability of this organ what is conected with diaphragm movement during breathing. The difference in localisation of the marker is observed between DRRs, simulation images and KV verification portal images.

Due to respiratory movement of the laesion we have to enlarge the margines arround the target what incrases the probability of toxicity of the treatment. The another solution is applying gating [38, 39, 40] which has been used in our department for a few years.

The combination of stereotactic fractionated radiotherapy, implantation of the marker and gating allow to perform high dose radiotherapy with very small risk of toxicity.

In the Department of Radiotherapy a treatment planning of the liver tumors is based on CT scans prepared in deep inspiration phase. This technique allows especially decreasing of a dose level at lungs due to lowest position of a diaphragm.

The marker localization in digitally reconstructed radiographs is an reference main point to subsequent correction of a patient position. The marker position during radiotherapy reflects displacement of an organ and the position correction based on a location of the marker is made.

The implantation of the gold marker to the liver doesn`t need any special patient preparation. Only the coagulation blood test is performed due to an invasive character of a procedure. The implantation of the marker is performed transcutaneus via under

ultrasonography guidance in sterile restriction without anesthesia. The needle used for implantation is very thin (25G diameter) and length ~~is~~ 120 mm (Fig. 1).

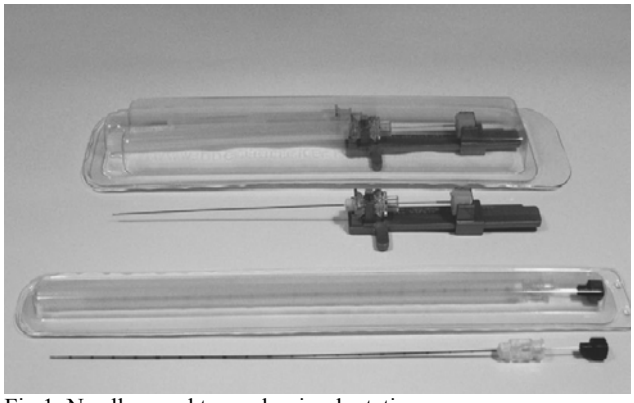

Fig 1. Needles used to marker implantation

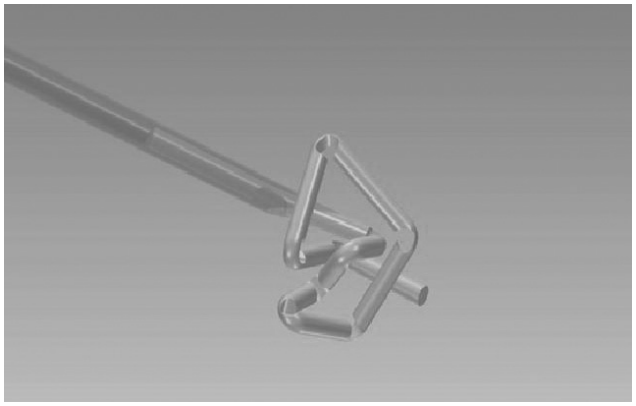

Fig 2. The Gold Anchor marker

The implantation directly into the tumor is not absolutely necessary. The close localization of the marker to the tumor is acceptable too.

The patient undergoing a few hours observation after implantation and the ultrasonography examination is made again to exclude the direct complications. The Gold Anchor marker is a gold wire which folds and collapses during implantation under pressure of the soft surrounding tissues. In result it achieves stabile three-dimensional form preventing migration (Fig 2).

The advantage of this method is a very small needle diameter what in consequence decreases probability of complications, pain escalation during implantation and risk of marker migration.

The next step is preparation of CT scans to treatment planning after one week from implantation (Fig 3). An interval between implantation and CT is important to full marker stabilization in tissues.

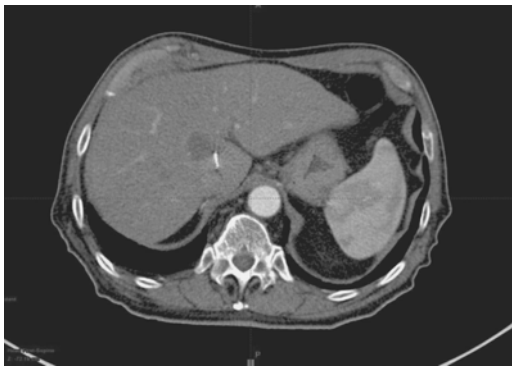

Fig 3. CT of the liver with implanted marker

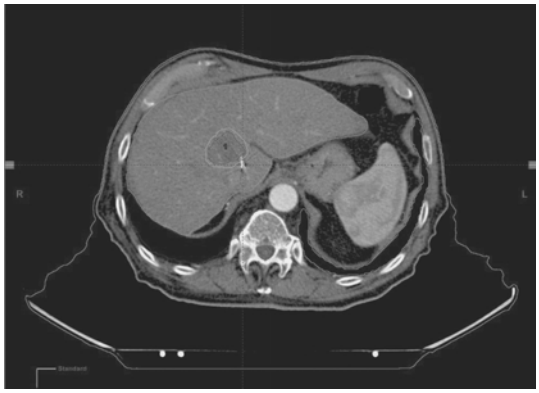

Fig 4. Delineation of the tumor, OARs and marker

The next phases are target and OARs (organs at risk) delineation (Fig 4), treatment plan preparation (Fig 5) and DRRs creation. The DRRs are necessary as a reference images to comparison with KV portal images prepared before each treatment session. There is two steps verification of the target position. Firstly KV portal images are made in 0 and 270 degrees gantry position and then initial correction of isocentrum position regarding bone structures is made. In second step analysation of patient's respiratory course (Fig 6) and second time KV images preparation in full inspiration phase and finally correction of the isocentrum position (Fig 7,8).

The marker is well visualized at DRRs and KV images too. The correction of table position is made manually after fusion of DRR and KV portal images. Using of

KV portal images results from our earlier experiences which demonstrated that this method is simple, fast, reliable in routine clinical practice [33, 41].

2D-2D KV system usage without marker implantation didn`t allow to perform verification of the soft tissues position of such liver tumors. It was the weakest part of this method. Nowadays the markers implantation makes possible to avoid such problems.

The invasive character of described method is undoubtedly the biggest disadvantage with small but real risk of complications possibility. On the other hand it allows to conduct position verification and precise irradiation simply and fast.

In wider perspective the usage of this method allows to decrease irradiated volumes due to possible margins decreasing. This fact is important especially in aspect of healthy tissues sparing and acute or late toxicity effects minimalization. Good protection of healthy tissues and precise localization of tumor allows to increase the total dose in target volume without increasing the risk of side effects [1].

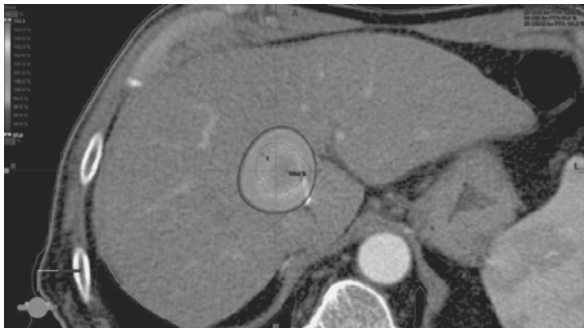

Fig 5 The treatment plan

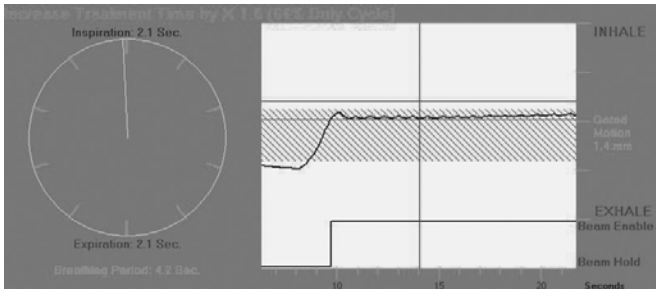

Fig 6.. Patient's respiratory course analization (deep inspiration)

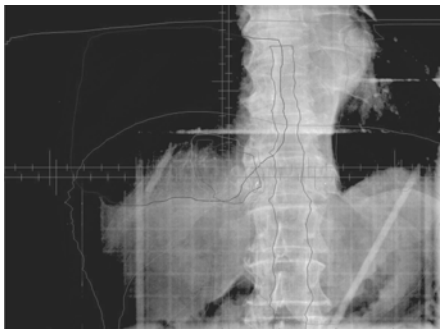

Fig 7. DRR and KV fusion (AP view)

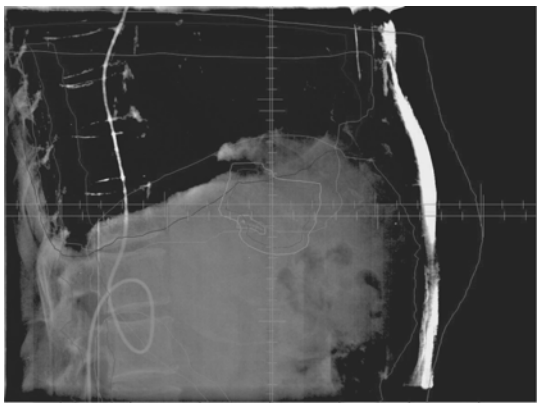

Fig 8. DRR and KV fusion (side view)

There weren't observed any complications among the patients connected with this procedure in our department. We are planning wider use of this markers to precise localizations of the tumors with high move ability such lung, pancreas and gynaecological tumors.

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