Arab Journal of Gastroenterology xxx (2017) xxx–xxx

Contents lists available at ScienceDirect

Arab Journal of Gastroenterology

journal homepage: www.elsevier.com/locate/ajg

Original article

Percutaneous ultrasound-guided fiducial marker placement for liver cancer robotic stereotactic radio-surgery treatment: A comparative analysis of three types of markers and needles

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ARTICLE INFO

Article history:
Received 6 October 2016
Accepted 7 May 2017
Available online xxxx

Keywords:
Stereotactic body radiation therapy
Fiducial markers
Liver neoplastic lesions
Ultrasound-guided percutaneous placement
Gold anchor marker

ABSTRACT

Background and study aims: Percutaneous placement of fiducial markers is required to perform stereotactic body radiation therapy (SBRT) for liver neoplastic lesions. This prospective trial was designed to evaluate the feasibility and safety of percutaneous ultrasound-guided placement of three different types of markers in patients with liver cancer referred for SBRT.

Patients and methods: Fifty patients underwent percutaneous ultrasound-guided implantation of a fiducial marker in the liver. Three sizes of needles were used: 25 gauge (G), 22 G, and 17 G. The 25 G and 22 G needles contained gold anchor markers of 0.28 × 10 mm and 0.4 × 10 mm size, respectively. In contrast, the 17 G needle contained a gold grain marker of 1 × 4 mm. Each patient received 1–6 markers, depending on lesion size and numbers. Technical feasibility and the occurrence of adverse events were registered. Computed tomography scans were acquired prior to SBRT to evaluate the location, visibility, or complications related to the markers.

Results: A total of 163 needles were used to deliver 163 markers in 50 patients. No major complications occurred. Minor complication occurrence rate was 12%. The total complication occurrence for all type of markers was 8.5%. No complications were observed with the use of the gold anchor marker of 0.4 × 10 mm size. Variance analysis of the three markers showed a significant difference in the frequency of complications amongst the three markers ($p < 0.01$).

Conclusion: Percutaneous ultrasound-guided placement of fiducial markers for SBRT of liver neoplastic lesions is safe and feasible. In our series, the 22 G needle showed some advantage in terms of handling and safety when compared with the 25 G and 17 G needles. In addition, the gold anchor marker of 0.4 × 10 mm size displayed a lower percentage of displacement.

Introduction

Surgery is the current standard treatment for localised operable neoplastic lesions of the liver [1]; however, many patients cannot afford surgical resection because of comorbidities, advanced age, disease extension, or patients' wishes. Treatment strategies for liver cancer have evolved over the last many years. Stereotactic body radiation therapy (SBRT) using the Cyberknife system is a non-surgical option for patients with inoperable or surgically complex tumours. In addition, it is an option in the case of absent response and/or relapse after chemotherapy and standard radiotherapy [2]. SBRT administers high doses of radiations that can reach any anatomic point with a sub-millimetric precision [3,4]. This high accuracy is achieved through a robotic image-guidance system technology and dynamic tracking of targets, with the removal of breathing artifacts. Through these techniques, the CyberKnife system can precisely hit the lesion with high doses of radiations whilst safeguarding the surrounding critical organs, which otherwise could be damaged [5,6]. Robotic radiosurgery can employ different systems for the localisation of the neoplastic targets for treatment. In particular, for the treatment of the solid organ tumours, CyberKnife uses a localisation system that is based on specific gold markers [7]. The placement of a fiducial marker

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http://dx.doi.org/10.1016/j.ajg.2017.05.007
1687-1979/

Please cite this article in press as: Marsico M et al. Percutaneous ultrasound-guided fiducial marker placement for liver cancer robotic stereotactic radio-surgery treatment: A comparative analysis of three types of markers and needles. Arab J Gastroenterol (2017), http://dx.doi.org/10.1016/j.ajg.2017.05.007

near the tumour before radiotherapy also allows respiratory motion to be tracked, thus enabling accurate dose delivery whilst the patient breathes freely [8]. Recently, the percutaneous insertion of fiducial markers has been described [9,10], but experience with such procedures is limited. The marker is made of gold, which makes it biocompatible and ensures good contrast on X-ray images.

The aim of the trial was to evaluate and compare the feasibility and technical benefits of percutaneous ultrasound (US)-guided placement of three different types of gold markers in patients with liver cancer referred for SBRT. We also evaluated the handling and safety of the three needles of different calibers that were used for fiducial deployment.

Patients and methods

This was a prospective, single-centre feasibility and comparative study conducted in a tertiary-care medical centre. Eighty patients affected by neoplastic disease with an indication for stereotactic radiotherapy were assessed. Thirty of them were excluded because they were affected by a primitive neoplasia of the pancreas in absence of liver lesion. Fifty patients affected by neoplastic liver lesions underwent percutaneous fiducial marker placement under US guidance. Written informed consent was obtained from all patients. All procedures were performed by two expert ultrasonographers using the ProSound Alfa7 (Hitachi-Aloka, Tokyo, Japan) equipment with a 3.75–7.5-MHz hemispheric sound technology 91–30 Multi Frequency Convex Abdominal probe. Local anaesthesia was achieved by the subcutaneous administration of 1% lidocaine. All gold fiducial markers were placed under US guidance through sub- or intercostal access. When the needle tip had reached the target lesion, the fiducial marker was deployed and the needle removed. We used three different types of needles: 25 gauge (G), 22 G, and 17 G. The 25 G needle contained 0.28×10 mm gold anchor marker, the 22 G needle contained 0.4×10 mm gold anchor marker, and the 17 G needle contained the 1×4 mm gold grain marker (Figs. 1 and 2). Every patient received 1 to 6 fiducial markers depending on the dimension and the number and location of the liver lesions. The fiducial positioning was assessed under US guidance as the marker is easily detected as a hyperechoic structure (Fig. 3). Seven days after the procedure, a computed tomography (CT) to identify marker location or possible complications was performed for all patients. Subsequently, two months after the SBRT treatment, another CT scan was performed to evaluate the response to radiotherapy. Technical success was defined as the successful placement of fiducial markers at the intended site. Clinical success was defined as the possibility to implement an adequate treatment plan with the markers retained at the correct position without migration. The following complications were evaluated: marker migration, marker shattering, marker not massed, presence of pneumothorax and/or bleeding, and death. Fiducial migration was defined as seed dislodgement outside the original injection site, making it unusable for guiding SBRT, as determined by CT scan (Fig. 4). All data

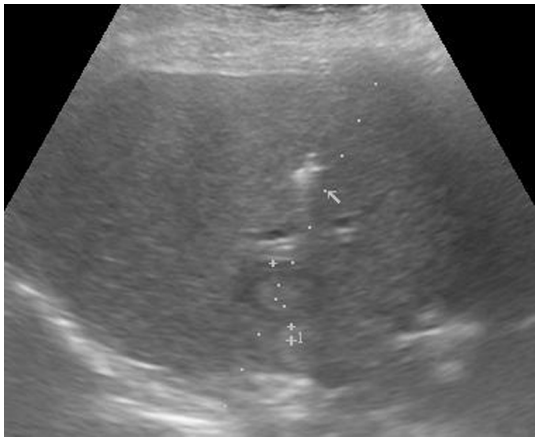

Fig. 3. Hyperechoic flexible-wire notched gold anchor marker (arrow) near a liver metastasis.

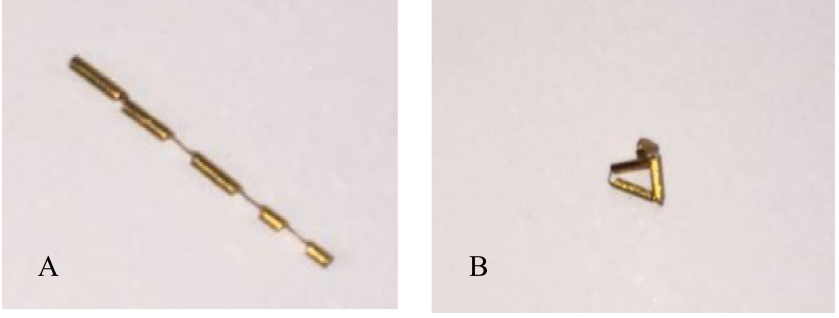

Fig. 1. Gold anchor marker 0.4×10 mm before (A) and after massing (B).

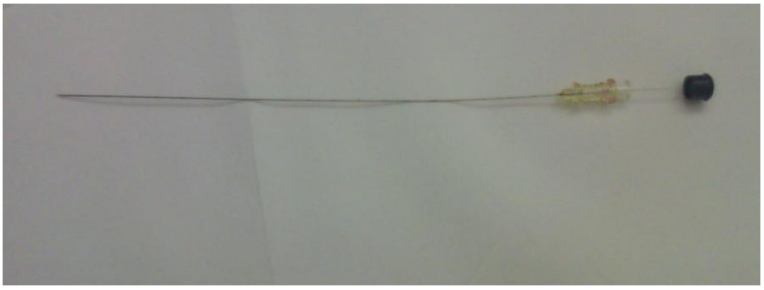

Fig. 2. 22-Gauge fine needle.

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