Short Communication

Unusual presentation of an extrahepatic migration of a fiducial implanted for stereotactic body radiotherapy

Meenu Jose, MBBS¹, George Shibu Pottikyal, MD², Ajay Sasidharan, MD¹, Sruthi K Reddy, MD¹, Annex Edappattu Haridas, MSc³ and Debnarayan Dutta, MD¹

¹Department of Radiation Oncology, Amrita Institute of Medical Science, Kochi, Kerala, India
²Department of Radiology, Amrita Institute of Medical Science, Kochi, Kerala, India
³Department of Medical Physics; Amrita Institute of Medical Science, Kochi, Kerala, India

Correspondence to: Debnarayan Dutta, MD, Department of Radiation Oncology, Amrita Institute of Medical Science, Ponekkara, Kochi, India 682026. Email: duttadeb07@gmail.com; Phone: +91 9884234290

(Received: October 17, 2020; Accepted: December 3, 2020)

Keywords: CyberKnife, extrahepatic migration, fiducial implant, hepatocellular carcinoma, portal vein thrombosis

INTRODUCTION

We report an unusual case of extrahepatic migration of fiducial in a patient diagnosed with hepatocellular carcinoma with portal vein thrombosis planned for stereotactic body radiotherapy (SBRT) using Cyberknife (CK). The fiducial migrated from liver to abdomen within one hour after placement and kept migrating for 24 h until it got lodged into the right gluteus maximus muscle. There was no complication reported. Patient was on follow up with regular observation. We are describing the potential migration pathway of fiducials after placement in liver, possible intervention procedures and the potential complications.

Fiducials or internal markers are an integral part of ‘real time’ tumour tracking. ‘Real time’ tumour tracking potentially reduces internal target volume (ITV) margin and hence reduces the high dose volume. Internal fiducials are useful for tumour tracking in image guided radiation therapy for mostly liver, lung and prostate cancer. Fiducial implantation is used for SBRT as surrogate for tumour motion in both linear accelerator based or CK radiosurgery platform (1-2). Implantation of fiducial markers is usually safe with very rare complications in less than 3% cases (3-6). Migration outside the implanted organ has been documented in less than 5% of cases (4, 7). However, fiducials have the potential to migrate in critical organs and have a potential to cause serious consequences (8-10). There is a need to track the potential path of migration and evaluate any need for intervention in situations where there is a potential for severe complication. In the present case scenario, the fiducial was displaced from the liver and the path of migration was documented with time interval images.

CASE HISTORY

A 60 year-old male diagnosed to have recurrent hepatocellular carcinoma with portal venous thrombosis, Barcelona Clinic Liver Cancer (BCLC) stage C, with Child Pugh A5 status, was planned for SBRT with CK radiosurgery platform. The patient had undergone three sessions of TACE in the last two years followed
by non-anatomical resection of liver nodule and CT guided microwave ablation of residual liver lesion in June 2020. In September 2020, the patient was diagnosed with recurrent lesions in segment IV and II with infiltrating left portal vein, causing portal venous thrombosis.

MIGRATION OF FIDUCIAL AND TREATMENT COURSE

Prior to radiotherapy simulation, implantation of gold fiducials was done by an interventional radiologist. Each fiducial is a cylinder made from 99 % pure gold with whorl on the surface. It weighs 17 gm and has a size of 1.2 mm x 5.0 mm. (GF1521 Gold fiducial marker, Mfg: IZI Medical products Owings Mills MD 21117 U.S.A). Three fiducials were implanted under computed tomography scan (CT) guidance using 20 cm long 18 gauge preloaded gold fiducial needles. Immediate post implantation check CT scan showed 3 fiducials in place in the liver (T0 hr). Post implantation 1 h (T1 h) check CT scan of abdomen on Day 0, revealed only two fiducials in place. Repeat whole body CT scan was performed at 2 h (T2 h) post-procedure to trace the missing fiducial, and the migrated fiducial was found in right gluteal region, within the gluteus maximus muscle (Figure 1). Repeat scan after 24 h (T24 h) showed that the fiducial in the pelvis to have moved from the previous position. At 48 h scan (T48 h), fiducial was seen stabilized in the pelvis (gluteus muscle) and not seen to change position. At Day 5, during treatment, a check scan showed that the fiducial was stabilized in the pelvis and not moved from its previous position. Patient completed the treatment and had no complaint of any pain or numbness in the right gluteal region.

DISCUSSION

Migration of the fiducial is rare but a known phenomenon. However, there is only limited literature on the timing of migration, time for settling down after migration, pathway for migration, complication with migrated fiducials and any management guidelines to tackle migrated fiducials.

Extra-hepatic migration after fiducial placement is rare and the common pathways for migration needs elaborate mention. Migration usually occurs through hepatic sinusoids, portal vein tributaries and also directly in the peritoneal cavity (coelomic spread) (8). Potential pathways for migration are described in figure 2. In case, fiducials are lodged in the hepatic sinusoids from which they enter the hepatic veins (hepatic veins), which join the inferior vena cava and enter the heart from which they can get into the lung parenchyma or systemic circulation (10). Hepatic veins are ‘valved’ and hence prevent retrograde flow. So fiducials from hepatic sinusoids are less likely to enter the heart or lung parenchyma. In case if the valves are damaged (infective etiology or due to back pressure), fiducials may land in the heart or lung. Weight of the fiducial also doesn’t allow them to be pushed up into the lung, rather they fall in the abdomen due to gravitational force. Hence, the possibility of fiducials from liver getting lodged in the heart or lung parenchyma and further progression into the circulation is relatively uncommon. Even if the fiducial get access to the lung parenchyma, the alveolar capillaries and venules usually prevent their further progress to heart and any other organ (e.g. brain). Hence fiducials have extremely rare possibility to get lodged in critical organs (e.g. brain, eye) and cause complications. Fiducial may rarely get access to the systemic circulation through pulmonary fistulas or shunts. Migration through the portal vein channel.
Unusual migration of fiducial

(tributaries) are more common. Larger diameter of portal vein tributaries allow fiducials to get lodged in it and being devoid of valves allows fiducials to move freely through the portal circulation. ‘Low pressure’ blood flow in the portal vein does not push the fiducials out of the vessels. Fiducials lodged in the portal venous system have the potential to get lodged in gastro-intestinal venous supply system and get lodged in any of the tributaries. Usually, there are various communicating channels in the tributaries and hence fiducials lodged in the tributaries do not cause any clinical complications. However, there is always a rare but potential possibility of venous occlusion and related complication.

Most common pathway for extra-hepatic migration is through the peritoneum or ‘trans-coelomic’ migration. Fiducials ‘fall’ in the peritoneal cavity and migrate through the cavity depending on the gravitational force and get lodged in the accessible dependent part of the peritoneal cavity. Fiducials migrated in the right side of the peritoneal cavity usually get lodged in the right para-colic gutter, sub-diaphragmatic pouch, renal pouch of Morrison or pouches around the duodenum (Figure 2). Fiducials in the left side of peritoneal usually get lodged in the splenic pouches, renal pouches or in the pelvic recesses (e.g. pouch of Douglas). Fiducials in the peritoneum settle only after a duration mostly due to fibrosis. ‘Clawed’ fiducials (fiducials with irregular surface) anchor early. Changing position of the patient has the potential to mobilize the fiducial and have further migration. Fiducials in the peritoneum usually don’t have the potential for any serious complication (rare complication is peritonitis) and are usually stabilized due to fibrosis. Migration to gall bladder has the potential for chemical peritonitis with serious complications. Surgical clips are smaller in size and lighter in weight, hence have higher potential for complications such as choledocholithiasis, duodenal ulcer, clip embolism, volvulus with bowel necrosis and colonic erosion (8).

Migration of fiducial is a known phenomenon, but the pathway for migration and time for ‘settlement’ is not appropriately documented (4, 5). As per convention, after fiducial placement usually 3 to 5 days interval is considered ideal time for ‘settlement’ of the fiducial. Hence, treatment is started 3-5 days after placement. ‘Settlement’ of the fiducial is believed to be due to fibrosis and incorporation of the metal within the tissue. Fibrosis may take 7 to 10 days and hence, many centres wait for a week after fiducial placement to start treatment. On the other hand, majority of the gross migration occurs within first 24 h after placement, and after 24 h migration occurs by a few millimetres only and occurs in less than 5% of cases. Rarely gross migration is reported after 24 h in fiducial placement. Minute migration after 24 h of placement does not affect the ‘rigid body’ error or fiducial tracking. In our prospective series, we have documented that gross fiducial migration occurs only within 24 h, hence treatment may be commenced after 24 h of fiducial placement (8). In the present report though the fiducial had migrated few times within 24 h, but after 1 day of fiducial placement fiducial was ‘settled’ and did not have any further migration till the completion of treatment (day 8). Hence, we may consider initiating treatment after 24 h of fiducial placement.

Another important issue is to locate the migrated fiducial in a case of migration. Most common site of

![Diagram showing possible pathways of fiducial migration after placement in the liver](image)

**Figure 2.** Diagram showing possible pathways of fiducial migration after placement in the liver.
gross migration from liver is in the abdomen through peritoneum or vein (portal vein). Hence, X-ray or CT scan of the whole abdomen and pelvis is mandatory to locate the migrated fiducial. Chest X-ray should be considered if fiducial is not located in the abdomen. Usually no active intervention is required in case of fiducial migration when there is no symptom. Repeat imaging follow up may be required till the fiducial is ‘settled’. In literature, extra-hepatic migration into the vein in hip has been reported where it remained lodged without any apparent clinical consequence (8). Intracardiac migration of hepatic fiducials has been reported which required active intervention (10). Hepatic infarction due to fiducial migration into right portal vein after 6 months of placement has also been reported. These reports suggests the possibility of fiducial migration through the hepatic venous circulation.

In summary, extra-hepatic migration of implanted gold fiducial is a rare complication, which may rarely have serious complications depending on lodgement site or organ. Serial imaging is recommended to track the fiducial, to know its course and attempt to retrieval must be done in the setting of anticipated complications. However in most cases with the fiducial being lodged in tissues such as muscle or fat, it may not lead to complications and can be observed.

ACKNOWLEDGMENTS

We thank the Department of Medical and Surgical Gastroenterology and Department of Radiology, Amrita Institute of Medical Science, Kochi, India for their support.

Authors’ disclosure of potential conflicts of interest

The authors have nothing to disclose.

Author contributions

Conception and design: Debnarayan Dutta, Sruithi Reddy, Ajay Sasidharan
Data collection: Meenu Jose, George Shibu, Annex H
Data analysis and interpretation: Debnarayan Dutta, Sruithi Reddy, Ajay Sasidharan
Manuscript writing: Debnarayan Dutta, Sruithi Reddy, Ajay Sasidharan, Meenu Jose
Final approval of manuscript: Debnarayan Dutta

REFERENCES

1. Y Seppenwoolde, W Wunderink, S R Wunderink-van Veen, P Storchi, A Méndez Romero, B J M Heijmen. Treatment precision of image-guided liver SBRT using implanted fiducial markers depends on marker-tumour distance. Phys Med Biology. 2011;56(17):5445-68
2. G Oldrini, H Taste-George, S Renard-Oldrini, A-S Baumann, V Marchesi, P Troufleau, D Peiffert, A Didot-Moisei, B Boyer, B Grignon, P Henrot. Implantation of fiducial markers in the liver for stereotactic body radiation therapy: Feasibility and results. Diagn Interv Imaging. 2015;96(6):589-592.
3. Park SH, Won HJ, Kim SY, Shin YM, Kim PN, Yoon SM, Park JH, Kim JH. Efficacy and safety of ultrasound-guided implantation of fiducial markers in the liver for stereotactic body radiation therapy. PLoS One. 2017;12(6):e0179676.
4. Kataki K, Dutta D, Madhavan R, Kalita M. Prospective Evaluation of Migration, Complications and utility of fiducial placement for CyberKnife treatment in hepatobiliary tumours. NJMR. 2020;10(1):10-15
5. Dutta D, Sathiyaa Krishnamoorthy S, Sudahar H, Muthukumaran M, Ramkumar T, Govindraj J. Robotic radiosurgery treatment in liver tumors: Early experience from an Indian center. South Asian J Cancer. 2018;7(3):175-182
6. Kothary N, Heit JJ, Louie JD, Kuo WT, Loo Jr BW, Koong A, Chang DT, Hovsepian D, Sze DY, Hofmann LV. Safety and efficacy of percutaneous fiducial marker implantation for image-guided radiation therapy. J Vasc Interv Radiol 2009; 20:235–239
7. Accuray Cyberknife treatment delivery system. Technical specifications. https://www.accuray.com/wp-content/uploads/cyberknife-treatment-delivery-system_-technical-specifications.pdf
8. Vedel PF, Wittendorf HE, Norus TP. Migration of clips to the colon after laparoscopic partial nephrectomy. BMJ Case Rep. 2017;2017:bcr2016219040.
9. Scher N, Bollet M, Bouilhol G, Tannouri R, Khemiri I, Vouillaume A, Sellami N, Eyben RV, Vannetzel JM, Darmon I, Rotenberg L, Lamallem H, Bauduceau O, Foster D, Toledano A. Safety and efficacy of fiducial marker implantation for robotic stereotactic body radiation therapy with fiducial tracking. Radiat Oncol. 2019; 14: 167
10. Trumm CG, Häussler SM, Muacevic A, Stahl R, Stintzing S, Paprottka PM, Strobl F, Jakobs TF, Reiser MF, Hoffmann RT. CT fluoroscopy-guided percutaneous fiducial marker placement for CyberKnife stereotactic radiosurgery: technical results and complications in 222 consecutive procedures. J Vasc Interv Radiol. 2014;25(5):760-8.