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Original Article

# Evaluation of the Setup Error using On-Board Imager (OBI) System in Upper Abdominal Cancer

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## Abstract

**Purpose:** To study the setup error of patient's positioning in upper abdominal cancer.

**Materials and Methods:** Eleven patients with upper abdominal cancer treated by 3D-CRT and IMRT techniques were studied during June 2008 to February 2009. Pre-treatment process began when two images in AP and Lat views of the patient were captured by using the OBI (Onboard Imager) System that attached with the linear accelerator machine. These two images were overlaid with the reference DRR (Digital reconstruction radiograph) of the planning CT (in the same views). As a consequence, the setup or couch position errors compared with the treatment planning values in three directions were calculated by the OBI software. Once the shifts applied, the couch had automatically moved to the right positions before treating the patient.

**Results:** For 134 OBI sessions, the average errors were 0.18±0.14 cm (0 - 0.7 cm), 0.24±0.22 cm (0-1.0 cm) and 0.21±0.18 cm (0 - 0.7 cm) in vertical (Vrt), longitudinal (Lng) and lateral (Lat) directions respectively. The maximum setup error was 1.0 cm in the Lng direction for a single patient. However, the errors within 0.5 cm in these three directions resulted as 99%, 88%, and 93%.

**Conclusion:** Most of the setup error values were acceptable within 0.5 cm in the entire directions; Vrt, Lng and Lat. Using OBI system, the patients were typically treated in the same position as mentioned in the treatment planning that helps to increase tumor control probability and decreasing complication rate.

## Introduction

In radiation therapy, patient's positioning and immobilization referred as a concerning process since the error of these processes may result in tumor control and patient complication. The optimization in radiotherapy functioned to deliver maximum dose to the tumor and minimum dose to the normal tissue. One method that increases efficiency according to the goal of radiotherapy would recognize ultimately on declining the setup error of patient's positioning and immobilization processes[1-3]. Therefore, it could be strongly supporting that the study of setup error from patient's positioning and immobilization was a crucial consideration. Numerous verification devices were implemented to check the patient's position before treatment such as port film[4,5], electronic portal imaging device (EPID)[6] and on-board imager (OBI)[7]. It was decided particularly for this case that, the patient's position was checked by using a kV OBI from Varian Medical Systems (Palo Alto, CA, USA). We selected this device as a result of, its high quality image, reducing radiation dose, having automated matching software and capability of shifting the couch automatically to the accurate position.

Fox et al[8] studied the performance of image registration software and repositioning 3D offset using OBI software. They tested precision and accuracy in known offset phantom (geometric rigid phantom and anthropomorphic head phantom). The accuracy of the OBI in detecting the positioning was represented with less than 1.4 mm for 3D vector offset (0.8 mm, 1.1 mm, and 0.4 mm in Vrt, Lng, and Lat directions respectively).

Perkins et al[9] analyzed the setup errors of thirteen patients with primary gastrointestinal cancer by using a kV OBI. The errors in three directions (Vrt, Lng, and Lat) were recorded with the average values of 0.32±0.42 cm (Vrt), 0.33±0.34 cm (Lng), and 0.35±0.39 cm (Lat). The percentage errors with equal to or less than 0.5 cm were 25% (Vrt), 28% (Lng), and 30% (Lat). They reported that by using OBI kV-kV matching, the uncertainty was reduced in amount of dose delivered, potentially resulting in improvement in local control and reduction in treatment toxicity.

This study was designed to evaluate the setup errors of the patient positioning for upper abdominal cancer in Radiation Oncology Unit, Chulabhorn Hospital.

## Materials and Methods

This study was retrospective of 134 sessions from 11 patients with upper abdominal cancer during June 2008 to February 2009.

Before starting to treat each patient, two images, AP (antero-posterior) and lateral were taken by utilizing the kV OBI attaching with the treatment machine of Varian Medical Systems (Palo Alto, CA, USA). These images were compared with the DRR (Digital Reconstructed Radiograph) generating from the planning CT images by using kV-kV matching software of the OBI as shown in Fig.1. The automatically matching of the images was performed first, however, if it was not proper matched, the manual matching with bony landmarks would be done by a radiation oncologist (in the first fraction). After the matching was accepted, the setup errors or couch shifting values in three directions, Vrt, Lng and Lat were determined by the software and the couch substantially moved into the correct positions after the shift was applied.

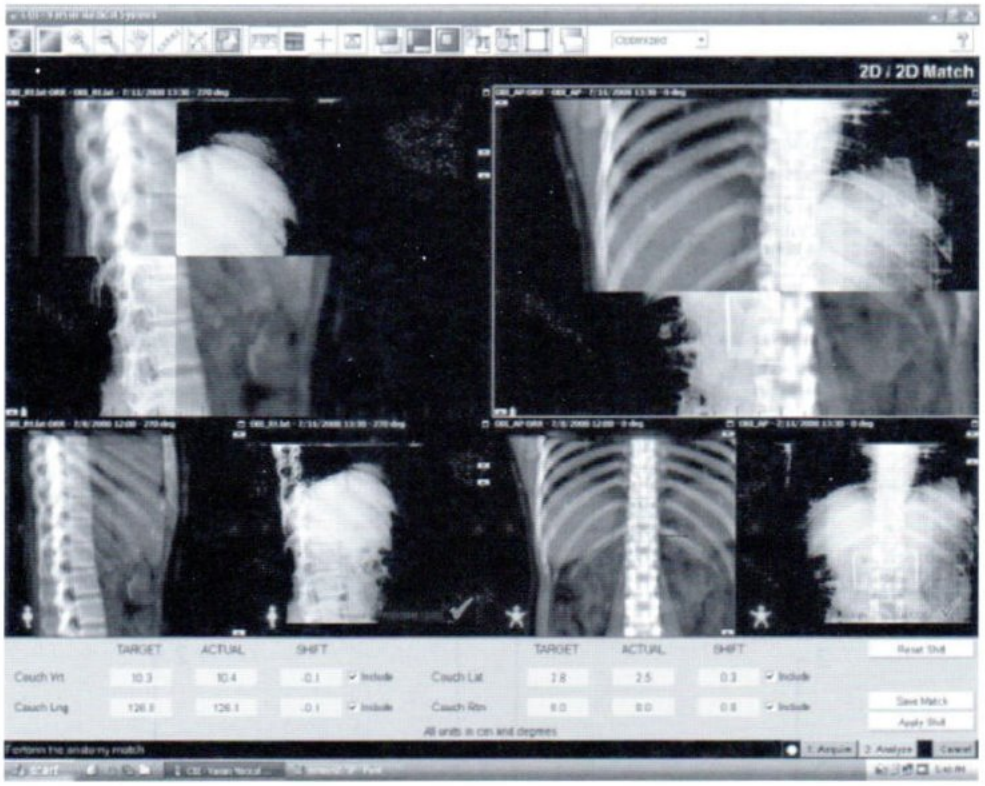


**Fig.1** The OBI console shows the overlaid images of OBI and reference images and couch shift (error) values

## Results

Table 1 shows the maximum, minimum and average values of the errors in the three directions for 134 OBI sessions of 11 patients. The maximum error was 1.0 cm in Vrt direction with the mean of 0.24±0.22 cm.

The frequency and percentage of errors in various ranges were summarized and shown in Table 2. The Vrt, Lng and Lat directions present the errors within 0.5 cm. with 99%, 88% and 93% respectively.

Fig.2 shows the scatter plots of the setup errors of each session in AP and Lat views. The errors of Lat direction shown in Fig.2(a) were almost in the positive (left) side of the patient which may affect from the systematic error.

**Table 1** Setup error of patient positioning for upper abdomen

| Vrt | | Lng | | Lat | |
|---|---|---|---|---|---|
| **Mean±SD** | **Min - Max** | **Mean±SD** | **Min - Max** | **Mean±SD** | **Min - Max** |
| 0.18±0.14 | 0 - 0.7 | 0.24±0.22 | 0 - 1.0 | 0.21±0.18 | 0 - 0.7 |

**Table 2** Frequency of setup errors in number of fractions and percentage in the three directions for various ranges of upper abdominal patients

| Error (cm) | Vrt | Lng | Lat |
|---|---|---|---|
| 0 - 0.1 | 71 *(53%)* | 58 *(43%)* | 59 *(44%)* |
| 0.2 - 0.3 | 44 *(33%)* | 44 *(33%)* | 47 *(36%)* |
| 0.4 - 0.5 | 18 *(13%)* | 17 *(12%)* | 18 *(13%)* |
| 0.6 - 0.7 | 1 (1%) | 13 (10%) | 10 (7%) |
| 0.8 - 0.9 | 0 (0%) | 1 (1%) | 0 (0%) |
| 1.0 - 1.1 | 0 (0%) | 1 (1%) | 0 (0%) |
| Total | 134 (100%) | 134 (100%) | 134 (100%) |

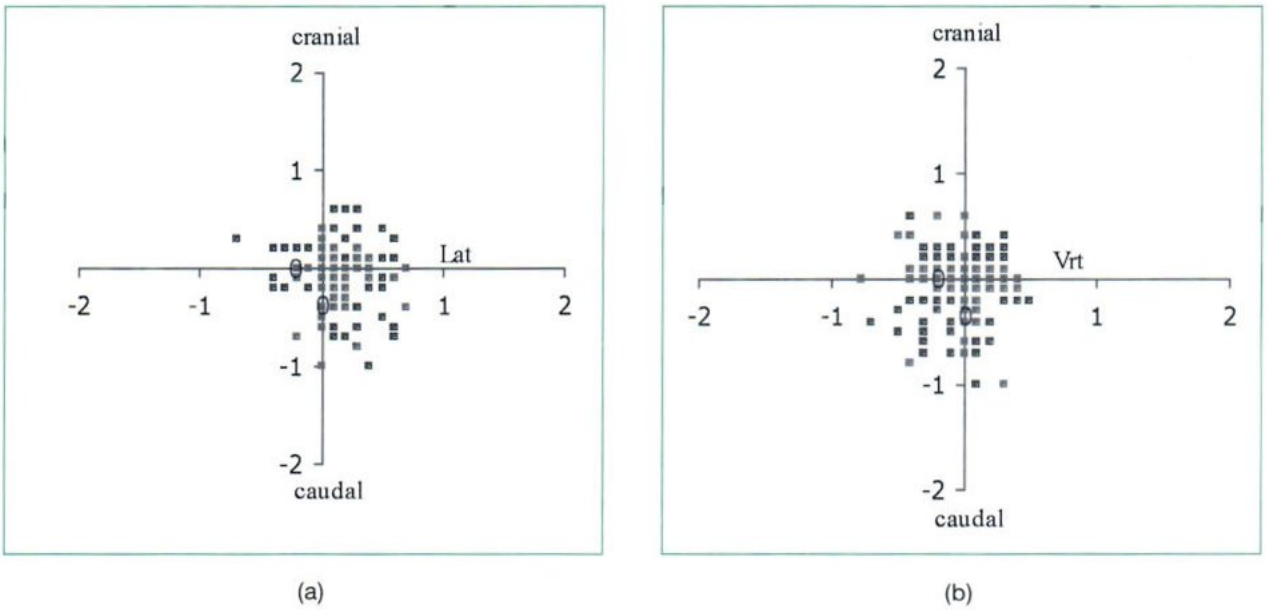


**Fig. 2** The scatter plots of setup error values: (a) AP and (b) lateral views of the images (Each point represents each session)

## Discussion

Our study showed a comparable result with the one of Perkins et al1 with the ratio, Perkins / this study as: (0.30±0.42) / (0.18±0.14), (0.33±0.34) / (0.24±0.22) and (0.35±0.39) / (0.21±0.22) in Vrt, Lng and Lat directions respectively.

For each patient, the majority errors were mostly appeared in the same sign of the co-ordinate for all directions with every session, hence these can be caused by the plan transferring error and the difference of the patient positioning on CT and treatment tables. When the error came out

apparently more than 0.5 cm, the condition of the patient had to be carefully considered and noted.

From the error values shown after image matching, the treatment couch can be automatically shifted to the right positions in the three directions before the treatment starts. The OBI is useful in external beam treatment as the patient was treated in the same position to the one used in the planning system. It results as high tumor control probability and low complication rate.

## Conclusion

Most setup error values of the three directions (Vrt, Lng, Lat) were measured within 0.5 cm. Only a single patient with fatty abdomen represented the error of 1.0 cm in the Lng direction for 2 sessions. A Vac-Lok may help to decrease the error of this patient but it could increase positioning setup time.

Whether institute where the OBI is not available, the larger PTV still be considerable. The OBI will be notified, when the tumor is close to a critical organ. Anyhow, if an internal organ movement from respiration takes place, more advance modality, respiratory gating is the concerning factor[10-12].

The comparison of positioning errors of the patient with and without Vac-Lok will be on-going for the further study[13].

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