Rep Pract Oncol Radiother, 2005; 10(5): 249-254

Original Paper

Received: 2005.01.31
Accepted: 2004.09.14
Published: 2005.11.15

A comparison of the dosimetric properties of The Electronic Portal Imaging Devices (EPIDs) LC250 and aS500

Bożena Woźniak, Małgorzata Ganowicz, Adam Bekman, Zbigniew Maniakowski

Institute of Oncology, Department of Medical Physics, Gliwice, Poland

The proceedings from the 3rd Congress of the Polish Society of Radiation Oncology. Technical, Biological, and Clinical Advances in Radiotherapy, 13-16 October 2004, Bydgoszcz.

Summary

Aim The aim of this paper was to compare the dosimetric properties of two different electronic portal imaging systems (EPID) used in the verification of doses.

Materials/Methods The Portal Vision (PV) LC250 and aS500 machines were used. The Portal Vision device is liquid-filled while the second machine is based on amorphous silicon. Stability and the reproducibility of signals were investigated. The relationship between the readings from EPID devices and the exit dose rate was established. Dependencies between the responses of the EPID signal and the field size, phantom thickness and source-detector distance were studied. The EPIDs measurements were compared with those from an ionization chamber in the slab phantom. The relationships were described using mathematical functions. All measurements made were based on a 6MV linear accelerator photon beam CLINAC 23EX (Varian).

Results Both devices are characterized by good stability and reproducibility. The dosimetric characteristics of EPIDs are different.

Conclusions The Portal Vision LC250 and the PV aS500 are attractive tools for dosimetry purposes. In the case of the liquid-filled PV, deformation of the beam image profile by setting-up of the gantry at angles other than 0 or 180 degree was observed.

Key words **electronic portal imaging device (EPID) • liquid-filled ionization chamber • amorphous silicon EPID**

Full-text PDF: http:/www.rpor.pl/pdf.php?MAN=8267

Word count: 1860
Tables: –
Figures: 7
References: 9

Author's address: Bożena Woźniak, Institute of Oncology, Department of Medical Physics, Wybrzeże Armii Krajowej 15 Str., 44-101 Gliwice, Poland, e-mail: bozenam@io.gliwice.pl

BACKGROUND

In recent years electronic portal imaging devices (EPID) have become a more and more indispensable tool for the verification of patient set-up in radiotherapy. It has proved to be an effective method for the visualization of the relative positions of anatomical structures within the radiation field and also for the determination of field size, shape, orientation and displacement errors at the time of treatment delivery [1]. The geometric accuracy of field placement may be determined by comparing a portal image to the original, pretreatment, simulation radiographs, radiographs digitally reconstructed from CT data-sets or to a previously approved portal image. Various types of EPIDs have been designed, though mainly the fluoroscopic-optical camera, scanning liquid-filled ionization and amorphous silicon type EPIDs have evolved into commercially available systems. More recently, EPIDs based on flat-panel amorphous silicon have been developed and show excellent image quality for the verification of treatment set-up, relatively high optical transfer efficiency, large imaging area and high resistance to radiation damage [2].

While EPIDs are primarily used for the assessment of patient positioning and beam alignment, they also represent an attractive method for the verification of a dose value [3–5]. It is possible to use portal dose information to determine patient dose values and, thereafter, to compare these values with those initially calculated by a treatment planning system. Therefore, in the case of their use in dosimetry, an investigation into their physical and dosimetric characteristics is essential.

AIM

The aim of this study was therefore to compare the dosimetric properties of two different electronic portal imaging systems (scanning liquid-filled ionization chamber (SLIC) and amorphous silicon (aSi)) in the verification of doses.

MATERIALS AND METHODS

The electronic portal imaging devices, LC250 and aS500, were used.

The Portal Vision ™LC250 (Varian Medical Systems) consists of a matrix of 256×256 liquid-filled ionization chambers which contain Is-octane to serve as an ionization medium between two electrodes formed by printed circuit boards (PCB) [6]. These ionization chambers are scanned row by row by switching on the polarizing voltage to the 256 electrodes on the front (PCB) while reading the induced signals from the corresponding electrodes on the back PCB. The electrodes on the back PCB are connected to electrometers. The matrix has a sensitive area of 32,5×32,5 cm^2 and pitch of 1.27 mm.

The Portal Vision ™aS500 (Varian Medical Systems) is the newest generation EPID based on amorphous silicon image detector technology [7]. This is an indirect detection system consisting of a 1 mm copper plate overlying a scintillating layer of phosphor, which converts incident radiation to photons. The generated light image is detected by an array of photocells etched into an amorphous silicon panel. Each pixel on the amorphous silicon panel consists of a light sensitive photocell and a thin film transistor, in which light is captured and converted into an electric charge. The thin film transistor acts as a switch controlling the signal readout, which is digitized by a digital converter. The sensitive area of the panel is 40×30 cm^2. The resolution of 512×384 pixels, with reference to the active image area, yields a spatial resolution of 0,784 mm.

All measurements were carried out using a CLINAC 23EX (Varian) accelerator at an accelerating potential of 6 MV.

The data from the EPID were exported (for further processing) to a numerical matrix (256×256 for LC250 model and 512×384 for aS500) using a special computer program.

Data for analysis was taken from binary files saved in the Portal Vision acquisition system.

One of the functions created by the authors of the software is the ability to convert binary image pixel files to text files, with an ROI option. This was an easy method for preparing data for further analysis in the calculation sheet. The format of the binary pixel file for the portal LC250 was supplied by the manufacturer [8]. For the aS500 EPID, the necessary file was compressed using a novel algorithm. In this case Dicom format binary files, exported from the Portal Vision were used. The programs, Borland Delphi and Microsoft Excel were used for this work.

In practice, it is difficult to deliver a completely flat radiation field to the detector. However for each field it is possible to define a small detector

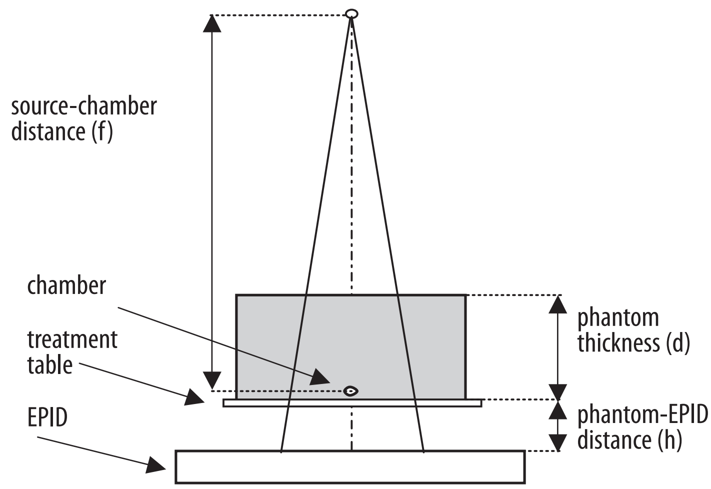

Figure 1. A schematic diagram of the experimental set-up for measurements.

region, for which the beam can be assumed to be a flat. In this study all EPID measurements have been averaged over a region 11×11 pixels on the beam axis, the region of interest, for the purpose of reducing the effects of pixel to pixel fluctuations. The standard acquisition mode was used, without correction, for our measurements.

The stability and reproducibility of signals were examined over a period of four months. The EPID measurements were compared with measurements from 0,6 cm^3 Farmer-Type PTW ionization chambers and electrometers (PTW Freiburg) in the slab phantom (on the central beam axis, with a source-chamber distance of 100 cm; the effective point of measurement was at the depth of maximum dose (d_{max}) 1,5 cm from the exit surface of the phantom).

In order to determine the relationship between the EPID signal, field side size (S) and phantom thickness (d), the EPID detector was positioned at various of distances (within a range from 120 to150 cm) from the source and the field size was set at the isocentre (from 6 to 24 cm) for different phantom thicknesses (6–20 cm). Measurements were normalized to 10×10 cm^2 values (at the isocentre) and to a phantom thickness 12 cm.

The influence of the source-EPID distance on the relationship between the exit dose rate (as measured by an ionization chamber) and the EPID signal was investigated at various phantom – EPID distances (h) from 18,5 to 48,5cm. The ion-chamber measurements were performed at various source-chamber distances (f) from 98 to 120cm and the EPID was positioned at ranges between 118 and 170 cm. The experimental set-up is presented in Figure 1.

Specific characteristics are used for the determination of calibration and correction factors, necessary in the calculation of exit dose values on the basis of the EPID signal [9]. Additionally, beam profiles at various gantry positions of the linear accelerator were checked using the PV LC250 and PV aS500.

RESULTS

Both Portal Vision systems are characterized by good reproducibility and stability of the signal in time. The calibration factors (which represent the relationship between dose rate measurements from ion chambers and EPID readings under reference conditions) were changed by less than 1% during a period of 4 months.

The relationship between dose, measured by ion-chamber, and the EPID signal for various source-chamber distances (f) was investigated as a function of the distance between the phantom and the EPID (h). This relationship – with a correction factor of $C_f(f,h)$ for the LC250 and for the aS500 – is presented in Figures 2,3.

For present dependencies, empirical functions were fit into the measured data (e.g.1,2).

EPID LC250:

$$C_f(f,h)=A_1\cdot f+A_2 \tag{1}$$

where:

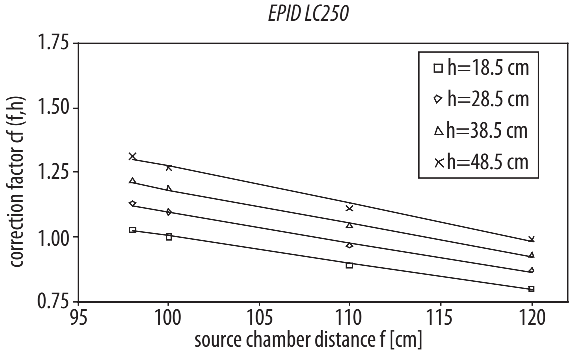

Figure 2. The relationship between dose rate measurements by ionization chamber and EPID signal for various distances (f) at the function of (h) – PV LC250.

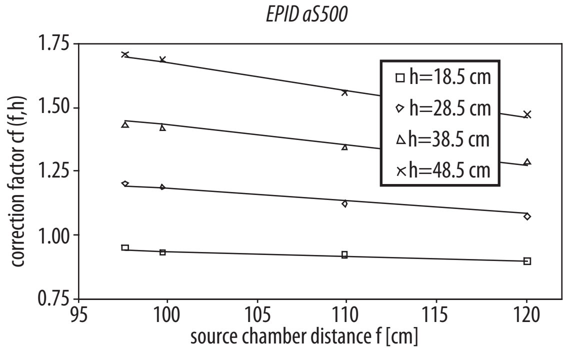

Figure 3. The relationship between dose rate measuring by ionization chamber and EPID signal for various distances (f) at the function of (h) –PV aS500.

$A_1=a_1 \cdot h+a_2$ $a_1=-0.000143$, $a_2=-0.007691$,
$A_2=a_3 \cdot h+a_4$ $a_3=0.023359$, $a_4=1.606245$.

EPID aS500:

$$C_f(f,h)=B_1 \cdot f+B_2 \qquad (2)$$

where:
$B_1=b_1 \cdot h+b_2$ $b_1=-0.000268$, $b_2=0.003055$,
$B_2=b_3 \cdot h+b_4$ $b_3=0.049228$, $b_4=0.284762$.

The correction factor $C_f(f,h)$ is a linear function of the distance f, and the regression parameters A and B are linear functions of h, for both models of EPID. The parameters a_i and b_i were calculated using a least-squares method. Statistical analysis showed good correlations between the fitted curves and measurement values for the two EPIDs. The average correlation coefficient, R, and the average determination coefficient, R^2 (as a function of h), were approximated for the LC250 and aS500 as follows: R=0,997 (SD=0,001); R^2=0,994 (SD=0,001), (p=0,004, Fisher's test) for the LC250 and R=0,973 (SD=0,019), R^2=0,948 (SD=0,037), (p=0,005, Fisher's test) for the aS500.

The relationships between EPID signals, field size (S) and phantom thickness (d) were studied. This relationship was not the same for both EPID models (Figures 4,5).

The determination of independent functions describing correction coefficients q(S,d) for EPID signals are necessary in both cases (e.g. 3,4).

EPID LC250:

$$q(S,d)=a_1 \cdot \ln(S)+a_2/S+a_3 \qquad (3)$$

where:
$a_i=a_{i1} \cdot \exp(-a_{i2} \cdot (d-a_{i3})^2)+a_{i4}$

	i=1	2	3	4
a_{i1}	–0.0484	0.0058	6.5665	0.1060
a_{i2}	–0.8571	0.0034	7.9090	0.9819
a_{i3}	0.5185	0.0027	1.8088	0.4331

EPID aS500:

$$q(S,d)=b_1 \cdot \ln(S)+b_2/S+b_3 \qquad (4)$$

where:
$b_i=b_{i1} \cdot d^2+b_{i2} \cdot d+b_{i3}$

	i=1	2	3
b_{i1}	–0.00201	0.04999	0.40129
b_{i2}	–0.02012	0.5865	0.4678
b_{i3}	0.00806	–0.0607	0.8342

Non-linear functions were applied to describe correction coefficients q(S,d). For both EPIDs the average correlation coefficient R was approximately 0,996 and R^2=0,991.

On the basis of our measurements we confirmed that the characteristics of field size are independent of source distance for both PV models. Additionally, readings from EPIDs, as a function of the source-EPID distance, are not dependent on the thickness of the phantom.

The measurements of beam profiles at different gantry positions of the linear accelerator show that the PVaS500 can be used at all gantry positions, but the PV LC250 is useful only at gantry positions 0° and 180°. At other gantry positions, deformation of the beam profile image,

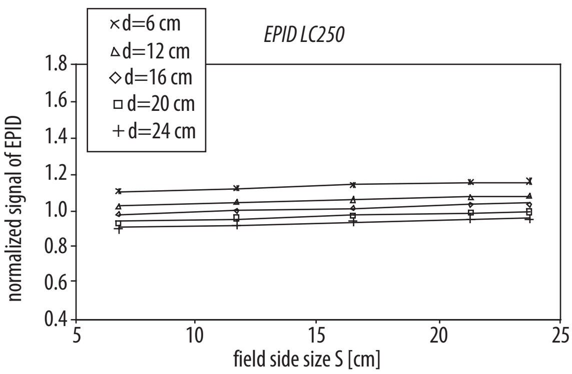

Figure 4. EPID signals (PV LC250) as a function of field side size (S) at varying phantom thicknesses (d).

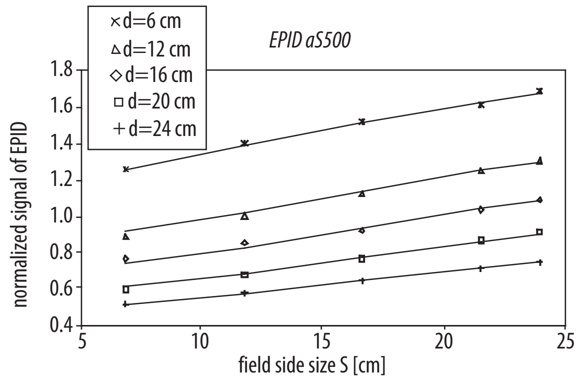

Figure 5. EPID signals (PV aS500) as a function of field side size (S) at varying phantom thicknesses (d).

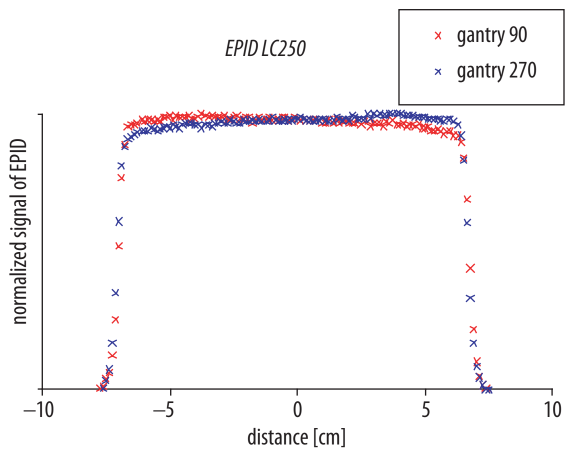

Figure 6. Beam profiles of square fields, measured using an EPID 140 cm from the source at 90° and 270° gantry positions of the linear accelerator (PV LC 250).

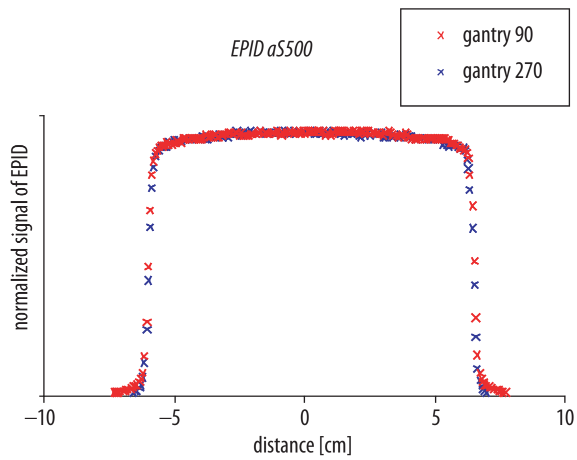

Figure 7. Beam profiles of square fields, measured using an EPID 140 cm from the source at 90° and 270° gantry positions of the linear accelerator (PV aS500).

as measured by the PV LC250, was observed (Figures 6,7).

Discussion

In this study, the main properties of SLIC and aSi EPIDs were investigated for the purpose of understanding their behaviour.

The correction factor $C_f(f,h)$ for the PV LC250 is dependent less on changes of phantom-EPID distance (h) than on the source-chamber distance (f). This situation is reversed in case of the second model (Figures 2,3).

The responses of EPIDs as a function of field size was dissimilar between EPID types (Figures 4,5). For the LC250 model, the coefficient q (S,d) varies within the range 0.85 to 1.12 for all examined thicknesses and field sizes (for a single thickness q(S,d) varies by around 5–6%). For the aS500 model, q (S,d) ranges from 0,49 to 1,71 for all examined thicknesses and field sizes (for a single thickness q(S,d) varies between 25–33%).

In future, other parameters such as photon beam energy and acquisition mode will be studied in order to fully understand the behaviour of EPIDs in all clinical situations.

Conclusions

The Portal Vision LC250 and the PV aS500 represent attractive tools for dosimetry purposes. The preparation of every Portal Vision system for dose measurements requires individual investigations into essential characteristics and the determination of empirical functions. In the case of the liquid-filled PV system, deformation of the profile beam image by setting of the gantry at positions other than 0 or 180 degrees was observed.

REFERENCES:

1. Kirby MC, Williams PC: The use of an electronic portal imaging device for exit dosimetry and quality control measurements. Int. J. Radiation Oncology Biol Phys, 1995; 31(3): 593–603
2. McDermott LN, Louwe RJW, Sonke J-J et al: Dose-response and ghosting effects of an amorphous silicon electronic portal imaging device. Med Phys, 2004; 31(2): 285–95
3. Parsaei H, El-Khatib E, Rajapakshe R: The use of an electronic portal imaging system to measure portal dose and portal dose profiles. Med Phys, 1998; 25: 1903–19
4. Vetterli D: Introduction of a novel dose saving acquisition mode for the Portal Vision™ aS500 EPID to facilitate on-line patient setup verification. Med Phys, 2004; 31: 828–31
5. Greer PB, Popescu CC: Dosimetric properties of an amorphous silicon electronic portal imaging device for verification of dynamic intensity modulated radiation therapy. Med Phys, 2003; 30: 1618–27
6. Esseres M, Hoogervorst BR, van Herk M et al: Dosimetric characteristics of a liquid-filled electronic portal imaging device. Int J Radiation Oncology Biol Phys, 1995; 5: 1265–72
7. Grein EE, Lee R, Luchka K: An investigation of a new amorphous silicon electronic portal imaging device for transit dosimetry. Med Phys, 2002; 29: 2262–8
8. Vision Application System Manual-Appendix A
9. Ganowicz M, Woźniak B, Bekman A, Maniakowski Z: Using an electronic portal imaging device for exit dose measurements in radiotherapy. Nowotwory, 2003; 6: 626–9