Assessment of ovarian movement on consecutive pelvic MRI scans for accurate radiotherapy planning in patients with gynaecological malignancies

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Introduction

When young women undergo radical pelvic radiotherapy for a gynaecological malignancy, there is a risk of premature menopause and infertility due to the high radiation dose received by the ovaries, also known as ovarian ablation. In current clinical practice, this is either accepted as a known complication of the procedure or the ovaries are surgically transposed out of the pelvis to reduce the received dose below the ablation threshold. In both cases, future pregnancies would require either donor ova or in vitro fertilisation (IVF).

With the recent technical improvements in radiotherapy, such as decreasing the size of the radiation field, reduce the dose to critical structures close to the high dose area, and the ability to plan treatment on Magnetic Resonance Imaging (MRI) examinations, the position of the ovaries can be delineated prior to the procedure and therefore the radiation dose to the ovaries can be reduced. However, ovaries are known to move within the pelvis every day[1]. Therefore a safety margin has to be included around the ovaries to account for ovarian movement to ensure that the ovaries are not covered by the high radiation dose. However, to date, no information is available on the extent of ovarian movement over time to deduce what margins should be added to the position of the ovaries to avoid ovarian ablation. Therefore we assessed ovarian position on consecutive MRI examinations to determine the extent of ovarian movement and provide a safety volume around the ovaries accounting for ovarian movement to avoid ovarian ablation and resulting premature menopause and infertility during pelvic irradiation.

Materials & Methods

Patients aged 18-80 years with advanced cervical, endometrial and vaginal cancer that underwent external beam radiation therapy followed by brachytherapy and had consecutive MRI examinations of the pelvis between November 2008 and June 2010 were eligible for inclusion. The study was approved by the local ethics committee. MRI examinations included axial and sagittal T2-weighted images with the ovaries included in the field of view on both series and the L5-S1 intervertebral disc included on the sagittal images. The position of the ovaries was determined by a radiologist (ES) with 8 years of experience in pelvic MRI by retrospectively reviewing the MRI examinations. Axial and sagittal images were shown on adjacent monitors on a dedicated workstation (Advanced Workstation, GE Healthcare, Waukesha, WI). Two reference lines were superimposed onto the images to determine the position of the ovaries relative to a bony reference point. A horizontal reference line was positioned on the sagittal images perpendicular to the centre of the anterior margin of the L5-S1 intervertebral disc and copied to all slices. The second reference line was positioned on the axial images, from the pubic symphysis anteriorly and through the centre of the sacrum posteriorly and copied to all slices. The cranio-caudal and antero-posterior position of the ovaries was determined on the sagittal images. Positive values were assigned to the position of the ovaries if the ovaries were positioned below and posterior to the reference line for the cranio-caudal and antero-posterior direction respectively. If the ovaries were located above or anterior to the reference line, negative values were assigned to the ovarian position. The medio-lateral position of both ovaries was determined on the axial images. If the left ovary was positioned on the left side of the reference line and the right ovary on the right side, positive values were assigned to the position, in all other cases medio-lateral ovarian position was assigned a negative value. All measurements were repeated on the second MRI examination of the same patient using the same method. Cranio-caudal, antero-posterior and medio-lateral position of the ovaries as determined on the second MRI study was subtracted from the position in three directions as determined on the first study and reported in millimetres (mm). Movement in cranial, anterior and medial direction was defined as positive movement and movement in caudal, posterior and lateral direction as negative movement. The safety volumes were derived as follows: reference intervals were calculated for both the left and right ovaries (the 95% and 99% reference intervals were defined as mean ± 1.96 sd and mean ± 2.58 sd respectively). Overall safety volumes in cranio-caudal, antero-posterior and medio-lateral direction were estimated by using the 95% and 99% reference intervals for both ovaries and volumes bound within a 3-dimensional ellipse which was defined as $v=4/3\pi \cdot xyz$ (R version 2.5.1, The R Foundation for Statistical Computing, Vienna, Austria).

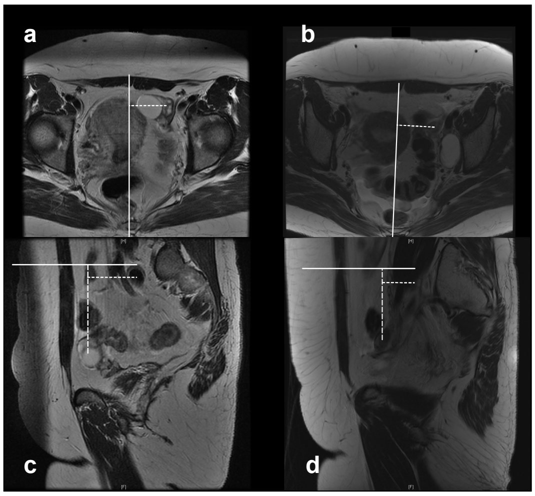

FIGURE 1. Typical example of the assessment of movement of the left ovary in a 37-year old patient with node positive stage IB1 cervical cancer (not shown). Left-sided lymphocele and a small amount of free fluid noted on the 2nd MRI examination (b). The left ovary moved 13 mm, -10 mm and 0 mm in cranio-caudal, antero-posterior and medio-lateral direction respectively between the first (a, c) and second (b, d) MRI examination.

Results

Thirty patients with advanced cervical (n=28), endometrial (n=1) and vaginal cancer (n=1) who underwent successive MRI examinations of the pelvis before and during radiotherapy treatment were included in our study. The mean time between consecutive MRI scans was 79 days (range 23-331 days). Both ovaries could be identified all cases. An example of the assessment of the movement of the left ovary is shown in Figure 1. Based on derived reference intervals (Table 1), safety volumes accounting for ovarian movement for the 95% and 99% reference interval would encompass 32 and 74 cm^3 for the left ovary and 57 and 129 cm^3 for the right ovary respectively.

	Left ovary	Right ovary
Cranio-caudal movement		
95% RI	59 mm *(-31 – +28 mm)*	56 mm *(-31 – +25 mm)*
99% RI	78 mm *(-41 – +37 mm)*	74 mm *(-40 – +34 mm)*
Antero-posterior movement		
95% RI	38 mm *(-23 – +15 mm)*	63 mm *(-33 – +30 mm)*
99% RI	50 mm *(-29 – +21 mm)*	83 mm *(-43 – +40 mm)*
Medio-lateral movement		
95% RI	27 mm *(-14 – +13 mm)*	31 mm *(-18 – +13 mm)*
99% RI	36 mm *(-18 – +18 mm)*	40 mm *(-23 – +17 mm)*
Safety volumes		
95% safety volume	32 cc	57 cc
99% safety volume	74 cc	129 cc

TABLE 1. 95% and 99% reference intervals and safety volumes accounting for ovarian movement. RI: reference interval.

Conclusion

Adding a safety volume around the ovaries to account for ovarian movement could reduce the high radiation dose to the ovaries during pelvic radiotherapy and ovarian ablation and resulting premature menopause and infertility could possibly be avoided.

References [1] Williams P, Warwick R. Gray's anatomy. Churchill Livingstone, London, UK, 1980.