

# Radiographer Delivered Fluoroscopy Reduces Radiation Exposure During Endoscopic Urological Procedures

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Accepted: 29th May 2015

Provenance: externally peer reviewed

## ABSTRACT

**Introduction:** The 1999 Ionising Radiation Regulations recommend that medical professionals using ionising radiation should aim to keep exposure as ‘low as reasonably practicable’. Urologists regularly use fluoroscopy during endoscopic surgical procedures. In some institutions, this is delivered by a radiographer whereas in others, it is delivered by the urological surgeon.

**Objectives:** To determine if radiographer-delivered fluoroscopy can reduce the exposure to ionising radiation during urological procedures.

**Methods:** An analysis of 395 consecutive patients, who underwent endoscopic urological procedures requiring fluoroscopy, was performed simultaneously across two institutions, over a 4 month period. 321 patients were matched and included in the analysis.

**Results:** Radiographer delivered fluoroscopy was associated with reduced ionising radiation exposure for retrograde pyelography procedures ED 0.09626 vs. 1.323 mSev,  $p=0.0003$ , and endoscopic stone surgeries ED 0.3066 Vs. 0.5416 mSev,  $p=0.0039$ , but not for ureterorenoscopic stone surgeries 0.4880 vs. 0.2213 mSev,  $p=0.8292$ .

**Conclusion:** Radiographer delivered fluoroscopy could reduce the patient’s exposure to ionising radiation for some urological procedures.

**Keywords:** Urology, endoscopic surgery, radiation exposure, ionising radiation

## INTRODUCTION

Endourology is a branch of urology that specialises in the minimally invasive telescopic inspection of the urinary tract.<sup>1</sup> This is a subspecialty that has evolved thanks in part to fluoroscopy, which allows real-time imaging during procedures such as nephrostomy insertion, retrograde ureteropyelography, flexible ureterorenoscopy (FURS) and percutaneous nephrolithotomy (PCNL). Fluoroscopy is thought to deliver lower doses of radiation in comparison to conventional radiography, however the duration and complexity of the procedure all have an impact on the overall effective radiation dose.<sup>2</sup> Fluoroscopy utilises ionising radiation,<sup>3</sup> and it is believed that exposure to large quantities of ionising radiation can create DNA-damaging free radicals, making it a potent carcinogen.<sup>4,7</sup>

The use of fluoroscopy is essential to urological practice and as such, adherence to legislation and best practice guidelines is crucial to maintain staff and patient safety. UK legislation on radiation protection dictates that radiation exposure should be kept to the ‘low as reasonably achievable’ (ALARA) principle.<sup>8</sup> The International Committee for Radiation Protection (ICRP) believe that not enough is being done to minimise ionising radiation doses.<sup>9-10</sup> It is recommended to use pulsed rather than continuous fluoroscopy wherever

possible, to keep a careful record of all exposure times and ensuring the field of view is minimised in order to reduce exposure time and effective dose.<sup>2</sup> Thus far, research has been concentrated on staff protection but more consideration must be given to the effective dose of radiation supplied to the patient.

Current practice in urology differs, with some institutions requiring a radiographer to administer fluoroscopy and others allowing the urological surgeon to use fluoroscopy as necessary. Radiographers have been found to deliver consistently low exposure times and effective radiation doses, equivalent to, and sometimes less than those of senior radiologists, perhaps due to a systematic approach more adherent to procedure and increased familiarity with the equipment.<sup>11-12</sup> The aim of this study was to determine if radiographer-delivered fluoroscopy could reduce ionising radiation exposure to the patient during urological procedures, by comparing the effective radiation dose with that of urologist delivered fluoroscopy.

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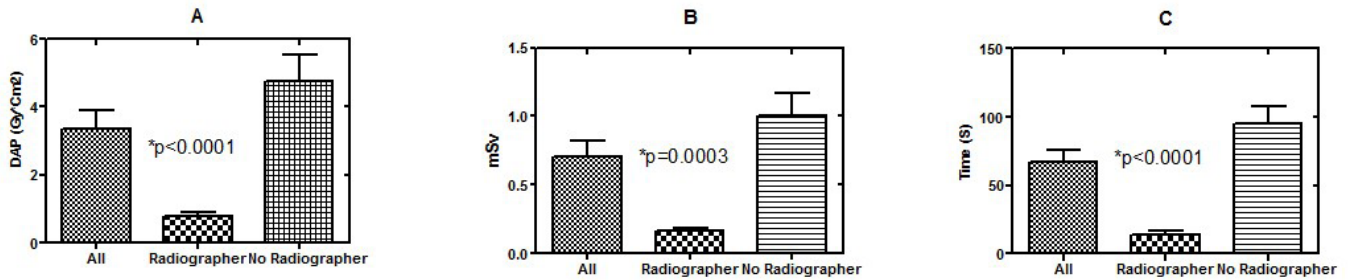


Fig 1. The use of a radiographer significantly reduced DAP (A), ED (B) and exposure time (C) for all retrograde pyelography procedures requiring fluoroscopy.

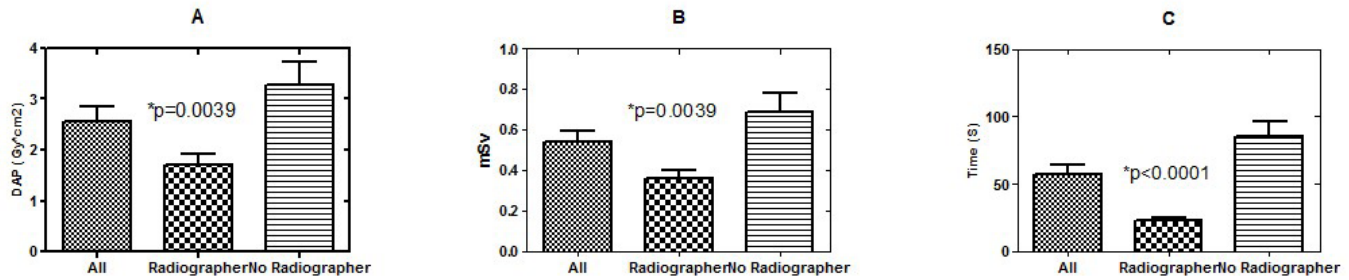


Fig 2. The use of a radiographer significantly reduced DAP (A), ED (B) and exposure time (C) for all ureteroscopic stone procedures requiring fluoroscopy.

**METHODS**

A prospective analysis of consecutive patients requiring fluoroscopy during endoscopic urological procedures was undertaken in two institutions over a 4 month period. Procedures included in this study were retrograde pyelography and stent placement procedures, semi-rigid ureteroscopic stone surgery and flexible ureterorenoscopic (FURS) procedures, for both therapeutic and diagnostic purposes. All procedures were carried out by either a consultant urologist or a senior urology trainee under consultant supervision.

Data was collected on 395 consecutive patients from both institutions [208 patients from Craigavon Hospital (CAH), 187 from the Causeway Hospital (CWH)]. Recorded data included: procedure type, indication, radiation exposure (cGy\*cm<sup>2</sup>, and fluoroscopy time in seconds. Both institutions used similar fluoroscopy machines Ziehm Vision, (Ziehm Imaging GmbH). Fluoroscopy was delivered by a radiographer in CAH, whereas in CWH radiation was delivered by a surgeon.

In the data analysis, cGy\*cm<sup>2</sup> was converted to Gy\*cm<sup>2</sup> to determine the dose area product (DAP). The effective dose (ED), measured in *millisievert* (mSv) was determined from the DAP by the Monte Carlo conversion.<sup>13</sup> Unless otherwise stated, data is represented as median (interquartile range: IQR) and N represents the number of patients included in the analysis. Differences in distribution of clinical data and the development of a SSI were evaluated using non-parametric t test. All calculations were done using Prism version 5.0 (GraphPad Software, Inc., La Jolla, CA).

**RESULTS**

*Procedure selection*

A total of 395 consecutive patients from both institutions were analysed and matched according to procedure, difficulty and delivery of radiation (radiographer vs. no radiographer). 74 procedures were excluded from the study because there was no corresponding match, specifically nephrostomy insertion and PCNL procedures. 321 patients were matched and included in this analysis (119 from CAH and 184 from CWH). Procedures included 79 retrograde pyelography and stent placements (28 CAH, 51 CWH), 100 ureteroscopic stone surgeries (45 CAH, 55 CWH) and 142 FURS procedures (61 CAH, 81 CWH).

*Retrograde pyelography procedures*

The median DAP for all retrograde procedures was 1.276 (0.4400 - 4.669) Gy\*cm<sup>2</sup>, the ED was 0.9805 (0.0924 - 0.9805) mSv and the median exposure time was 24.00 (7.0 - 126.0) seconds. Radiographer-delivered fluoroscopy produced a median DAP of 0.4584 (0.3850 - 1.247) Gy\*cm<sup>2</sup>, the ED was 0.09626 (0.08085 - 0.2619) mSv and the exposure time was 8.5 (4.0 - 22.5) seconds. When fluoroscopy was used by the surgeon, the DAP was 3.320 (0.8100 - 6.299) Gy\*cm<sup>2</sup>, the ED was 1.323 (0.6972 - 1.323) mSv and the exposure time was 54.00 (14.00 - 149.0) seconds. Radiographers significantly reduced the DAP 0.4584 Vs. 3.320 Gy\*cm<sup>2</sup>, p < 0.0001, the ED 0.09626 vs. 1.323 mSv, p = 0.0003 and the exposure time 8.5 vs. 54 seconds, p < 0.0001. (Figure 1)

*Ureteroscopic stone treatment procedures*

The median DAP for all ureteroscopic procedures was 2.040 (0.8265 - 3.222) Gy\*cm<sup>2</sup>, the ED was 0.4284 (0.1736 - 0.6767) mSv and the median exposure time was 32.5 (17.0 - 62.5) seconds. Radiographer-delivered fluoroscopy produced a median DAP of 1.460 (0.3180 - 2.675) Gy\*cm<sup>2</sup>, the ED

was 0.3066 (0.06678- 0.5618) mSv and the exposure time was 19.00 (14.00 - 28.50) seconds. When fluoroscopy was delivered by the surgeon, the DAP was 2.579 (1.248 - 4.049) Gy\*cm<sup>2</sup>, the ED was 0.5416 (0.2621 - 0.8503) mSv and the exposure time was 52.0 (32.0 - 129.0) seconds. Radiographers significantly reduced the DAP 1.460 Vs. 2.579 Gy\*cm<sup>2</sup>,  $p=0.0039$ , the ED 0.3066 Vs. 0.5416 mSv,  $p=0.0039$  and the exposure time 19.0 vs. 52.00 seconds,  $p < 0.0001$ . (Figure 2)

#### FURS procedures

The median DAP for all FURS procedures was 2.385 (1.054 - 4.380) Gy\*cm<sup>2</sup>, the ED was 0.5171 (0.2213 - 0.9314) mSv and the median exposure time was 59.0 (31.75 - 98.25) seconds. The median DAP for diagnostic FURS procedures was 1.585 (0.5520 - 2.690) Gy\*cm<sup>2</sup>, the ED is 0.3330 (0.1159 - 0.5649) mSv and the median exposure time was 52.00 (28.50 - 105.0) seconds. (Figure 3)

Radiographer-delivered fluoroscopy for diagnostic FURS, produce a median DAP of 2.324 (0.9780 - 3.060) Gy\*cm<sup>2</sup>, the ED was 0.4880 (0.2054 - 0.6426) mSv and the exposure time was 32.00 (23.50 - 81.51) seconds. When fluoroscopy was delivered by the surgeon, the DAP was 1.054 (0.4862 - 2.099) Gy\*cm<sup>2</sup>, the ED was 0.2213 (0.1021 - 0.4408) mSv and the exposure time was 75.00 (36.00 - 123.0) seconds. Radiographers did not reduce the DAP 2.324 vs. 1.054 Gy\*cm<sup>2</sup>,  $p=0.8292$ , the ED 0.4880 vs. 0.2213 mSv,  $p=0.8292$ . However the exposure time was reduced time 32.0 vs. 75.00 seconds,  $p=0.0297$ . (Figure 4)

Radiographer-delivered fluoroscopy for therapeutic FURS produced similar findings. The median DAP was 3.570 (1.778 - 5.658) Gy\*cm<sup>2</sup>, the ED was 0.7497 (0.3733-1.188) mSv and the exposure time was 56.50 (26.75 -75.50) seconds.

When fluoroscopy was delivered by the surgeon, the DAP was 2.728 (1.616 - 6.245) Gy\*cm<sup>2</sup>, the ED was 0.5729 (0.3393- 1.311) mSv and the exposure time was 64.00 (49.50 - 141.0) seconds. Radiographers did not significantly reduced the DAP 3.570 Vs. 2.728 Gy\*cm<sup>2</sup>,  $p=0.2156$ , the ED 0.7497 vs. 0.5729 mSv,  $p=0.2156$  and the exposure time 56.50 vs. 64.0 seconds,  $p=0.0003$ . (Figure 5)

#### DISCUSSION

Endourological procedures, such as diagnostic retrograde pyelography, semi-rigid ureteroscopy, FURS and PCNL, are heavily reliant on the use of ionising radiation through fluoroscopy. The Society of Radiographers state, that "radiation protection principles and UK legislation is the responsibility of all professionals working with radiation".<sup>13-14</sup> We compared two departments utilising different methods of ionising radiation delivery, with the view that radiographer-delivered fluoroscopy could deliver a lower effective radiation dose to the patient.

Dose area product (DAP) and effective doses (ED) are variable depending on procedure type and difficulty, however the International Atomic Energy Agency, have compiled data recommending safe effective doses for a variety of procedures across specialties.<sup>15</sup> This has recommended mean doses of 1.3mSv for both semi-rigid and flexible ureterorenoscopic laser lithotripsy procedures and 4.7mSv for ureteric stent placement. Overall, our effective doses compare favourably, with doses far lower than the accepted averages across all procedure types irrelevant of fluoroscopy delivery method. This was particularly apparent in retrograde pyelography and ureteric stent procedures where the average effective radiation dose was only 0.9mSv. This difference could be explained by the use of modern digital fluoroscopic machines, as well as the

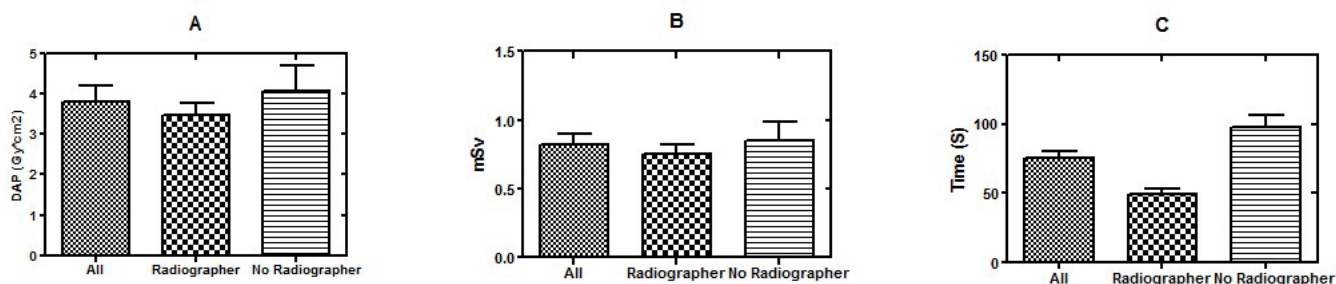


Fig 3. DAP (A), ED (B) and exposure time (C) for all FURS procedures.

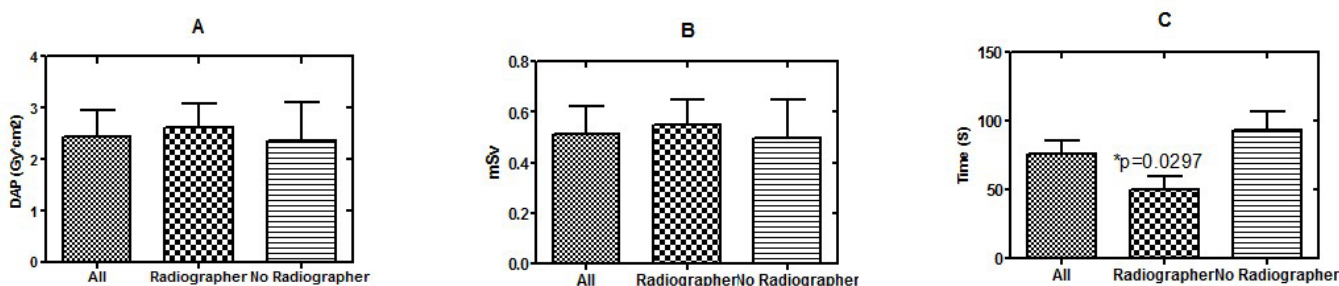


Fig 4. Radiographers did not reduce the DAP, the ED 0.4880 for FURS procedures. However the exposure time was reduced time,  $p=0.0297$ .

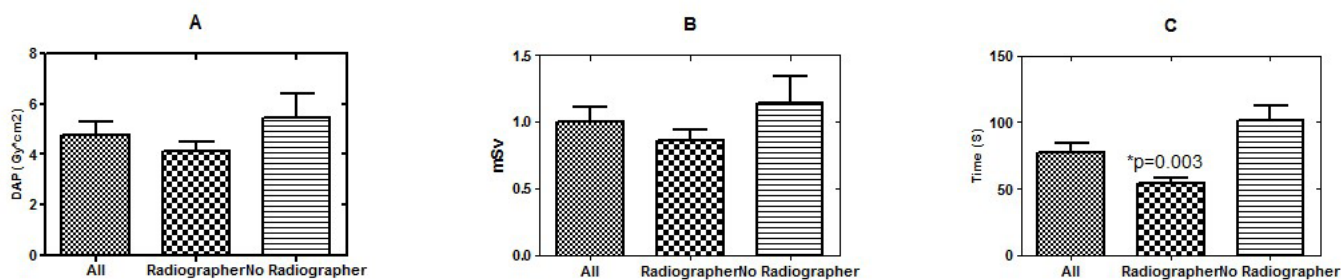


Fig 5. Radiographers did not reduce the DAP, the ED for FURS stones procedures. However the exposure time was reduced time,  $p=0.003$ .

use of a number of optimisation techniques designed to reduce ED, such as limiting radiation scatter with a scatter grid, beam collimation, using pulsed rather than continuous fluoroscopy and reducing the area of the radiation field<sup>16</sup>

Direct comparison of radiographer-delivered fluoroscopy (CAH) to urologist-delivered fluoroscopy (CWH) has produced variable results. Retrograde pyelography with ureteric stent and all semi-rigid ureteroscopy (URS) procedures demonstrated a significant difference between the two methods. Radiographer-delivered fluoroscopy has produced significantly lower DAP, ED and exposure time for both procedures. Very low effective radiation doses of 0.09mSv for retrograde pyelography and 0.3mSv for semi-rigid URS were recorded, which compared with 1.3mSv and 1.5mSv of urologist delivered radiation is a significant finding. There could be a number of possible reasons why radiographers are performing better. Radiographers receive formal qualifications in the delivery of ionising radiation, and may have a greater awareness of adherence to the ‘ALARA’ principle than doctors. Radiographers have been found to use less ionising radiation than some consultant radiologists, when performing complex procedures requiring fluoroscopy.<sup>11,12</sup> They use fluoroscopy routinely, providing a greater familiarity with and knowledge of the equipment.

The results for FURS (flexible ureterorenoscopy) did not demonstrate that radiographers significantly reduced the ED. There is no IAEA recommended mean ED for FURS, but it is expected that radiation dose would be higher. This is because FURS predominantly focuses on fluoroscopy in the vicinity of the kidneys, which have variable anatomical positions and move with respiration, making appropriate positioning more difficult for a radiographer less familiar with anatomy than a surgeon.

The urologist-delivered ED for both diagnostic and therapeutic FURS was lower, recording doses of 0.22mSv and 0.57mSv respectively. Overall exposure time, however were higher, measuring 75secs compared to 32secs for diagnostic, and 64secs compared to 56secs for therapeutic. This lack of correlation between ED and exposure time may be explained by Peach et al, who propose that doctors can better position the patient anatomically than radiographers, enabling short spells of continuous fluoroscopy, rather than repeated fluoroscopy from multiple incorrectly positioned attempts.<sup>17</sup>

Consideration must be given to the skill of the urologist

delivering radiation. Interventional radiologist or ‘operator controlled’ fluoroscopy during complex vascular procedures, has been found to use a reduced effective dose in comparison to radiographers, concluding that the better quality imaging equipment and experience of the consultant interventional radiologist were the reason for this.<sup>17</sup> This concept of increased familiarity with fluoroscopy equipment may be relevant to reduce effective radiation doses further, one study in particular found that over a two year period, exposure time for semi-rigid ureteroscopy fell by 78% for one operating surgeon as they became more familiar with the procedure.<sup>18</sup>

## CONCLUSION

This research has suggested that radiographer-delivered fluoroscopy could reduce the effective radiation dose delivered to patients undergoing certain endourological procedures. We believe this is due to greater knowledge and experience, increased familiarity with fluoroscopic equipment and better knowledge of optimisation techniques. Urologists delivering fluoroscopy should have a greater consideration of the radiation doses they are administering and take steps to reduce it, particularly for retrograde pyelography and semi-rigid URS. Everyone involved in the administration of ionising radiation should adhere to the ‘ALARA’ principle, even if operative radiation doses are already lower than IAEA recommended levels.

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