

Dose reduction in evacuation proctography

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Abstract The goal of this study was to reduce the patient radiation dose from evacuation proctography. Ninety-eight consecutive adult patients referred for proctography to investigate difficult rectal evacuation were studied using a digital imaging system with either a standard digital program for barium examinations, a reduced dose digital program (both with and without additional copper filtration), or Video fluoroscopy. Dose-area products were recorded for each examination and the groups were compared. All four protocols produced technically acceptable examinations. The low-

dose program with copper filtration (median dose 382 cGy cm²) and Video fluoroscopy (median dose 705 cGy cm²) were associated with significantly less dose than other groups ($p < 0.0001$). Patient dose during evacuation proctography can be reduced significantly without compromising the diagnostic quality of the examination. A digital program with added copper filtration conveyed the lowest dose.

Key words Defecography · Dosimetry · Rectum radiography · Digital radiography

Introduction

Evacuation proctography (EP) is a radiological technique that images rectal evacuation of a barium paste in order to diagnose structural and functional anorectal abnormalities. Most patients are referred for EP because of constipation, particularly difficult rectal evacuation, and most patients with severe constipation are women. In one series all of the patients considered for colectomy were female [1]. Many of these women are of childbearing age, so that inevitable pelvic irradiation during EP has attracted understandable criticism. Most investigators broadly base their examination on the description by Mahieu et al. [2], but there is considerable variation in filming technique. Video fluoroscopy or 105-mm spot films can be used to record rectal evacuation. Video incurs a lower dose but does not have the spatial resolution of spot filming so that a combination of the two is frequently used. Cine radiography has been abandoned because of the radiation penalty. A previous

study of the radiation dose during EP using an analogue system concluded that the technique was associated with a “considerable” dose, and 19% of these patients were women under the age of 40 years [3]. Newer digital fluoroscopy systems allow more control over exposure factors, raising the possibility of dose reduction, and are becoming more common in practice [4]. The aim of this study was to compare the dose conveyed by a digital fluoroscopy system with conventional video fluoroscopy during evacuation proctography.

Patients and methods

Ninety-eight consecutive adult patients undergoing EP for the investigation of difficult rectal evacuation were studied prospectively. Their mean age was 49.6 years (age range 26–78 years). Twenty-three patients (23.5%) were under 40 years of age. There were only two men.

One hundred millilitres of barium suspension (Baritop 100% w/v, Bioglan Laboratories, Hitchin) was added to 200 ml of water.

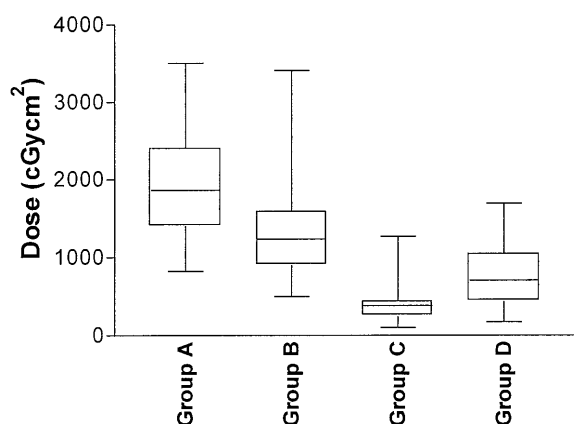


Fig. 1 Comparison of patient dose during evacuation proctography in patients examined using a standard digital program for barium examinations (group A), a reduced-dose digital program (group B), a reduced-dose digital program with additional copper filtration (group C), and Video fluoroscopy (group D). $p < 0.0001$, Kruskal-Wallis test. Horizontal bars median values

Ten millilitres of Gastrografin was added and this solution was given orally 30–60 min before the procedure in order to opacify the small bowel so that enterocoeles could be diagnosed. Twenty minutes before the procedure, two glycerine suppositories were given rectally and patients were instructed to defecate. Evacuation proctography was then performed using a standard technique [5]. With the patient in the left lateral position on the fluoroscopy table, the rectum was filled with 120 ml of barium paste (E-Z-paste, E-Z-Em, Westbury, N. Y.) instilled via a bladder syringe. The fluoroscopy table was then brought upright. The patient was seated on a specially designed commode placed on the footstep and instructed to defecate as rapidly and completely as possible during imaging.

Consecutive patients were respectively assigned to the following four exposure protocols, using the same digital control unit (Siemens Display Plus and Sireskop 5, Siemens plc, Bracknell, Berkshire, UK; Fig. 1) with inherent filtration equivalent to 0.3 mm aluminium: group A, 12 patients were examined using a standard digital program for barium examinations exposed at one frame per second, at 125 kV; group B, 17 patients were examined using a reduced dose digital program, created by altering the automatic exposure curves via software to achieve a 50% dose reduction, and exposed at one frame per second; group C, 41 patients were examined using the reduced dose program exposed at one frame per second with 2-mm copper filtration added to the tube; and group D, 28 patients underwent lateral video recording during fluoroscopy, with the examination saved to S-VHS videotape for review. The tube distance was constant throughout at 1.5 m. For the first three groups screening fluoroscopy at 99 kV was used to image the patient into the correct position before exposure began. Total dose was recorded at the end of each examination from a Diamentor PTW M2 dose area product (DAP) meter measuring centi-Gray per square centimetre (cGy cm^2). Since the examination dose was to be related to rectal evacuation time, total examination time was calculated for groups A, B and C by adding positional screening time to the number of spot films taken. For group D, total examination time equalled total screening time. All 98 examinations were reported by a consultant radiologist (S.H. or C.I.B.) and the image quality of each scored as either acceptable or unacceptable.

Rectal evacuation times would not be expected to be normally distributed because patients with prolonged evacuation tend to skew any large distribution to the right. This was confirmed using the Shapiro-Wilk test statistic. The total dose for patients in each group was therefore compared using the Kruskal-Wallis test statistic, with Dunn's post-testing to identify differences between individual groups. Calculations were performed using Arcus Quickstat Biomedical 1.2 (Research Solutions, Cambridge, UK) and statistical significance assigned at a probability level of < 0.05 .

Results

All 98 examinations were deemed to be of acceptable diagnostic quality. In particular, the inevitable loss of spatial resolution in groups C and D (copper plate and video fluoroscopy groups, respectively) was not felt to impair study interpretation. There was no significant difference in the median examination times for each group: group A = 40.5 s; group B = 50 s; group C = 31 s; and group D = 36 s ($p = 0.085$, Kruskal-Wallis test).

The median dose conveyed to individual groups was: group A, 1859 cGycm^2 (range 822–3503 cGycm^2); group B, 1234 cGycm^2 (range 499–3409 cGycm^2); group C, 382 cGycm^2 (range 101–1266 cGycm^2); and group D, 705 cGycm^2 (range 174–1689 cGycm^2). There was a highly significant difference between group medians ($p < 0.0001$), with only the individual comparison between group A (standard program) and B (reduced dose program) failing to reach statistical significance on post-testing (groups A vs C, $p < 0.0001$; groups A vs D, $p < 0.0001$; groups B vs C, $p < 0.0001$; groups B vs D, $p = 0.0002$; groups C vs D, $p < 0.0001$).

Discussion

Evacuation proctography has considerable therapeutic impact in patients complaining of difficult rectal evacuation, and is a pivotal investigation in deciding between surgical or conservative therapy [6]. Many patients are women of childbearing age; thus, there is a natural reluctance to limit pelvic irradiation in this group; 23.5% of our patients were under 40 years of age. Evacuation proctography has been described as "among the radiological procedures associated with a relatively high exposure" [3]. However, the abnormalities of rectal configuration revealed by EP do not need high spatial resolution for diagnosis, allowing spatial resolution to be traded for decreased patient dose.

We found that satisfactory examinations were obtained using all of the exposure protocols investigated. Indeed, before we acquired our digital unit we used an entirely video-based analogue unit for several years. Its spatial resolution was less than any of the protocols tested here but was still adequate for diagnosis. Furthermore, many patients who complain of constipation

have a functional disorder of evacuation. These patients exhibit prolonged evacuation, which is the most specific proctographic feature in this subgroup [5]. Because of potentially extended examination times in these subjects, any technique that reduces patient dose would be advantageous. The wide variation in individual dose within groups is due to variability in evacuation times.

We use a digital system for EP. Digital systems are likely to convey lower doses than analogue equipment. A study that compared analogue and digital systems in over 10,000 barium studies found that digital systems were associated with an approximately twofold lower dose-area product [4]. Using an analogue system for EP in 67 consecutive patients, Goei and Kemerink found a mean effective dose equivalent of 4.9 mSv for women and 0.6 mSv for men [3]. Bartram and co-workers estimated a skin dose to the right hip of between 0.02 and 0.66 cGy for proctography, again using an analogue system [7]. We used a dose-area product meter measuring centi-Grey per square centimetre, a system that is simple to use, readily available and directly related to individual patient dose.

Although the median dose conveyed by the reduced dose program was lower than the standard program (1234 vs 1859 cGycm², respectively), this did not reach statistical significance on post-testing. The addition of the copper filter to this protocol resulted in the lowest dose of all, median 382 cGycm², which was significantly smaller than all other groups. The video protocol (median dose 705 cGycm²) also conveyed a significantly lower dose than either the standard or reduced-dose program, but remained significantly higher than with

copper-added filtration. Added copper filtration has been applied to paediatric double-contrast barium enema examinations and has been found to significantly reduce dose without impairing diagnostic quality [8].

The major benefit of video is its ability to replay the entire examination at any speed, a feature which can be useful when attempting to diagnose internal rectal intussusception in a patient with rapid evacuation, whereas the edit mode is used to review digital examinations frame by frame. Although tapes are relatively expensive, each will contain many examinations and individual hard copy requires a video printer. Some authors recommend squeezing, cough and stress views before asking the patient to evacuate [9], whereas others may perform additional screening specifically designed to image enterocoeles [10]. Additional examination in the coronal plane also increases dose but may be necessary to diagnose intussusception that is not apparent on a lateral view [11]. For this study we used a simplified EP technique, imaging only during evacuation to minimise exposure.

In conclusion, we employed a variety of techniques in combination with a digital imaging system in an attempt to reduce patient dose during evacuation proctography. Patient dose can be reduced significantly without compromising the diagnostic capabilities of the examination. A low-dose digital program with added copper filtration conveyed the least dose.

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