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FULL PAPER

Randomized comparison of long and short vascular sheaths in reduction of the operator radiation exposure during uterine artery embolization

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Objective: To introduce a method in which a long sheath is used instead of the traditional short sheath, to reduce the radiation exposure of operators in uterine artery embolization (UAE).

Methods: 52 patients undergoing UAE were randomly divided into two groups before the procedure: an 11-cm short sheath was used in Group A ($n = 25$), and a 45-cm-long sheath was used in Group B ($n = 27$); the 45-cm-long sheath was only partly inserted such that the hub of the sheath was approximately 34 cm caudal to the groin puncture site. All the procedures were standard bilateral UAE operations through unilateral approach. The other parameters of the two groups were kept the same, including the fluoroscopy conditions and the pelvic radiation field size. The thermoluminescent personal dosimeters were attached to the left wrist and left outer side of the thyroid collar of the operator during each operation. The radiation exposure of the operator,

procedure duration and fluoroscopy time of each procedure were recorded. Statistical analysis was performed using independent samples t -test.

Results: The radiation exposure of both the left hand and thyroid of the operator was significantly reduced with the long sheath compared with the short sheath ($89.5 \pm 7.2 \mu\text{Gy}$ vs $186.7 \pm 12.6 \mu\text{Gy}$, $p < 0.001$, and $54.1 \pm 5.5 \mu\text{Gy}$ vs $63.9 \pm 7.4 \mu\text{Gy}$, $p < 0.001$, respectively). No significant differences were found in the procedure duration and fluoroscopy time between the two groups ($p > 0.1$).

Conclusion: Using a long sheath in UAE could significantly reduce the radiation exposure to the interventionists without extending the procedure duration or fluoroscopy time.

Advances in knowledge: For the first time, we introduce a simple and convenient method to reduce the radiation exposure of the operator in the UAE procedure.

INTRODUCTION

Uterine artery embolization (UAE) has received great popularity and wide application.¹ However, radiation exposure of the operator during UAE has received little attention.^{2,3} The use of the femoral approach for UAE puts the operator, and especially the left hand, close to the primary beam, one major reason being that the currently used sheath is only 11-cm long. Operator exposure can be reduced by increasing the distance from the radiation source (the inverse-square law).⁴ Few effective methods have been reported regarding the reduction of operator radiation exposure. Based on the distance protection principles, we introduced a method in which a long sheath is used to extend the distance between the radiation field

and the operators. We conducted a randomized comparison of long and short vascular sheaths, to observe differences in operator radiation exposure. To the best of our knowledge, there has been limited literature available on the use of long sheaths in the UAE procedure.

METHODS AND MATERIALS

Patients

The present study was a randomized, prospective, single-centre study that compared long and short sheaths with respect to their ability to reduce operator radiation exposure. This study was conducted in the Department of Radiology, Renji Hospital, School of Medicine, Shanghai Jiao Tong University between September 2010 and March 2012.

Inclusion criteria for this study were essentially symptomatic uterine fibroids. Symptoms required for inclusion were one or more of the following: pelvic pain, abnormal menstrual bleeding or bulk-related symptoms attributed to tumours (e.g. astriction, frequency of urination, vaginal pressure). Exclusion criteria included symptoms of an acute infection, gynaecologic malignancy or suspected malignant tumour, unexplained abnormal menstrual bleeding, coagulation disorders, ongoing pregnancy, severe renal failure or allergy to contrast agents. At last, a total of 52 female patients with ages ranging from 24 to 45 years (mean age of 35.60 ± 3.84 years) were enrolled in this study. Subjects were randomly assigned to either the short-sheath group (Group A) or the long-sheath group (Group B) by drawing lots. Group A included 25 patients (mean age 34.6 years; range 24–38 years) and Group B included 27 patients (mean age 36.5 years; range 29–45 years). The mean weight of the patients was significantly higher in the short-sheath group than in the long-sheath group (72.4 ± 13.5 kg vs 65.8 ± 15.2 kg, $p = 0.01$, respectively). Institutional review board approval for this study was granted by our institution, and written informed consent for the UAE procedure and the trial was obtained from all patients.

Uterine artery embolization technique

All procedures were performed by one experienced interventionist (WZ) in Renji Hospital, School of Medicine, Shanghai Jiao Tong University. The operator was blinded to the purpose of the exploration and data collection. Procedures were performed using the Siemens angiographic system (Artis zeego; Siemens, Forchheim, Germany). Patients were placed in the same position on the examination table during all procedures. 11-cm 5-F introducer sheaths (AVANTI® Introducer; Cordis

Corporation, Miami, FL) were employed in Group A, and 45-cm 5-F introducer sheaths (Avanti® Introducer) were employed in Group B (Figure 1). Bilateral uterine artery angiography and embolization were performed with unilateral right femoral artery access and Waltman loop technique in all cases. A 4-F Cobra™ catheter (COOK®, San Diego, CA) was placed in the uterine artery, and UAE was performed after a coaxial 2.6-F microcatheter (Stride; INTECC Co., Ltd, Japan) was advanced distally into the ascending branch of the uterine artery. In Group B, the 45-cm-long sheath was only partly inserted such that the hub of the sheath was approximately 34 cm caudal to the groin puncture site. The embolic agent was non-spherical polyvinyl alcohol particles (Alicon Medical Co., Ltd, Hangzhou, China) mixed with 100 ml of 1:1 saline solution and contrast agent mixture. Polyvinyl alcohol size varies between 350 and 700 microns. Embolization was determined to be complete, once the cessation of blood flow was achieved in the ascending uterine artery during 10 cardiac beats. At the end of the surgery, compression was applied to the puncture side for approximately 12–15 min or until haemostasis was achieved.

All the UAE procedures were performed under identical conditions, including the fluoroscopic parameters and radiation protection methods. The same radiation protection method was applied during each procedure, namely standard lead aprons, thyroid collars and lead glass shield (ceiling mounted).

Radiation exposure measurement

To monitor the interventionist radiation dose, Microstar personal thermoluminescent dosimeters (TLDs) (Landauer Corporation, Glenwood, IL) were used, which were appropriate for

Figure 1. (a) The long sheath used in Group B was fixed with a sticky surgical thin film. (b, c) The left hand was at least 34 cm away from the puncture site when using the long sheath in the surgery.

Table 1. The radiation exposure of the operator in uterine artery embolization

Parameter		Left hand		Thyroid	
		Group A	Group B	Group A	Group B
Radiation dose (μGy)	Mean $\pm$ SD	186.7 $\pm$ 12.6	89.5 $\pm$ 7.2	63.0 $\pm$ 7.4	54.1 $\pm$ 5.5
	Median (interquartile range)	189 (178–196)	89 (83–95)	63 (58–65)	53 (51–58)

SD, standard deviation.

extremity dosimetry.⁵ One TLD was attached to the left wrist on the palmar side and the other one was placed on the left outer side of the thyroid collar of the operator in each operation. The palmar side was chosen because the X-ray tube was located under the examination table; thus, this side was more likely to be directly exposed to the X-ray radiation. A finger TLD was not used because of the risk of impairing manual dexterity, and the wrist was a more appropriate location for the TLD than the finger. Data were collected after the completion of each procedure. Calibration TLD data provided by Shanghai Jiao Tong University dosimetry laboratory were used to establish the standard dose curve for the TLD using linear regression analysis in the study. Each TLD was calibrated for an 80-kVp beam, and the corresponding calibration factor was applied after the reading of the measurement was performed. The duration of the procedure and fluoroscopy time (minutes) were also recorded.

Statistical analysis

The data were presented as mean $\pm$ standard deviation. Differences were analyzed using independent samples *t*-test, and *p*-values <0.05 were considered significant.

All computations were performed using the SPSS® statistical software v. 18.0 (IBM Corp., New York, NY; formerly SPSS Inc., Chicago, IL).

RESULTS

All the patients ($n = 52$) undergoing UAE were analyzed in this study. The radiation exposure to the operator for the left hand and thyroid using long and short sheaths, respectively, is presented in Table 1. The radiation exposure to the operator was significantly reduced using the long sheath compared with the short sheath for the left wrist ($p < 0.001$). The radiation dose of

the thyroid was also significantly reduced ($p < 0.001$) (Figure 2). The fluoroscopic times were 21.6 ± 5.8 min for Group A and 22.4 ± 4.3 min for Group B, which were not significantly different ($p = 0.72$). There was also no significant difference in the procedure durations between Groups A and B (65.4 ± 3.6 min vs 63.7 ± 4.6 min, respectively; $p = 0.68$).

DISCUSSION

This study demonstrated that the use of a longer sheath significantly reduced operator radiation exposure to the left hand and thyroid under optimized radiation protection conditions. Moreover, the procedure duration and fluoroscopy time were not significantly different between the two groups.

Bilateral UAE is most commonly performed in patients with obstetrical and gynaecological diseases, and methods of radiation protection for these patients during UAE have been demonstrated.^{5–7} Many researchers have focused on patient radiation exposure in UAE. Nikolic et al² reported that the absorbed ovarian dose and absorbed skin dose during UAE could be reduced by using pulsed fluoroscopy instead of non-pulsed fluoroscopy. Current methods of radiation protection, such as achieving access through the left radial artery, have yielded good protection for interventionists during the catheterization of coronary arteries.⁸ However, little research has been conducted regarding the protection of interventionists during UAE. Therefore, a new method that increases the distance between the X-ray tube and interventionists has been proposed in our study, and preliminary results showed that this method could effectively reduce radiation exposure and may have potential benefits for operator health.

The large difference in operator doses indicates that protocol optimization and consistent use of protective shields and devices

Figure 2. (a) The use of a 45-cm-long sheath (Group B) resulted in a 52.0% reduction in radiation dose to the left hand compared with the 11-cm-long sheath (Group A) ($p < 0.001$). (b) The use of a 45-cm-long sheath (Group B) resulted in a 14.1% reduction in radiation dose to the thyroid compared with the 11-cm-long sheath (Group A) ($p < 0.001$).

may substantially reduce occupational radiation doses.⁹ The protection barrier primarily consists of a well-designed lead apron. A 0.35-mm-thick lead apron will provide the wearer with substantial protection.¹⁰ Photochromic sunglasses and spectacles with a high lead content afford the wearer some degree of eye protection.^{11,12} Lead rubber or other protective gloves can provide some protection to the hands, but these types of gloves are not routinely used because they reduce tactile sensitivity, which may result in an increase in fluoroscopy time. Intervention radiation exposure is also significantly influenced by the operation experience of the interventionists.⁹

Pron et al¹³ demonstrated that increased experience in UAE significantly reduced radiation exposure and fluoroscopy time. A reduction of approximately 50% in the received doses was observed between the first and second year of work owing to increased experience, resulting in reduced procedure times and fluoroscopy use, as reported by Anglesio et al.¹⁴ Operator hands often received much higher doses than the eyes, neck or trunk.¹⁵ Interventionist hands receive even higher doses than those by radiation therapist hands, most likely owing to the use of fluoroscopy during the interventional procedure.¹⁴ In our study, the application of a long sheath extended the distance from the radiation source and significantly reduced the radiation exposure to the hand and other organs. Remaining as far away as possible from the patient reduces the scattered radiation dose, as exposure level decreases with distance from the patient. It is worth mentioning that the long sheath added no additional fluoroscopy time compared with the time associated with the use of the traditional short sheath.

The long sheath must be fixed effectively to prevent the catheter from shifting during the procedure. This fixation was achieved by placing adhesive dressing in front of the patient leg and a surgical towel, which effectively prevented unexpected shifting of the long sheath during the procedure.

When the 45-cm-long sheath was used as a guide sheath, a 100-cm 4-F Cobra catheter was sufficient to complete the bilateral uterine artery catheterization, and the length of the catheter did not need to be extended. In the ipsilateral uterine artery catheterization, the Waltman loop was not affected after intubation. Overall, using the long sheath for guidance did not increase the difficulty of the UAE procedure, and it significantly

reduced the radiation exposure of the interventionist. Therefore, the use of the long sheath is highly recommended during the UAE procedure.

All the procedures were performed by one experienced interventionist. We also demonstrated that extending the sheath did not prolong the procedure or fluoroscopy time, suggesting that the long sheath may not increase the technical difficulties of the experienced operator. However, the difference in operator radiation exposure between the radial and femoral approaches has been reported to be inversely related to operator experience.^{16,17} Although the practice of only one interventionist to complete all of the procedures effectively avoided experimental errors related to the differences in operator experience, it also represents a limitation of our study. As a result, it is still unclear whether the use of the long sheath will increase the technical difficulties and prolong the fluoroscopy time of the less experienced operators. Therefore, further studies are needed. Another limitation of our method is that because there were no scales marked on the current sheath, we had to determine the correct head position while introducing the catheter into the sheath. It is suggested that the sheath should be marked with a scale every 5 cm during production to shorten the procedure time. A possible source of bias may be the higher mean body weight of patients in the short-sheath group than that of patients in the long-sheath group (72.4 ± 13.5 kg vs 65.8 ± 15.2 kg, respectively; $p = 0.01$), as body weight is positively correlated with fluoroscopy time and radiation exposure.¹⁸ More importantly, a significant amount of radiation scatter from the patients' pelvic bone structures should not be overlooked.¹⁹ Another limitation that cannot be ignored is the small patient population. A larger sample of patients is needed to strengthen the statistical power of this study. Overall, we introduced an effective method to decrease the radiation exposure of the operator, especially for the left hand, without prolonging the operation time. Based on our results, we believe that this method should be highly advocated in pelvic endovascular interventional operations.

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