Archives of Cardiovascular Disease (2009) **102**, 749—754

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CLINICAL RESEARCH

Impact of an extension tube on operator radiation exposure during coronary procedures performed through the radial approach

Impact d'un système de rallonge sur l'irradiation reçue par l'opérateur au cours d'une procédure de cardiologie interventionnelle par voie radiale

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Received 24 June 2009; received in revised form 27 August 2009; accepted 10 September 2009
Available online 14 November 2009

KEYWORDS
Coronary arteries;
Radial approach;
Radiation exposure;
Dosimeter

Summary

Background. — Operator radiation exposure is high during coronary procedures. The radial access decreases the rate of local vascular complications but increases operator radiation exposure. As the X-ray exposure is related to the distance between the operator and the radiation source, the use of an extension tube between the proximal part of the coronary catheter and the 'injection device' might decrease operator radiation exposure.

Aims. — To demonstrate that the use of an extension tube during coronary procedures performed through the radial approach decreases operator radiation.

Methods. — Overall, 230 patients were included consecutively and randomized to procedures performed with or without an extension tube. Radiation exposure measures were obtained using two electronic dosimeters, one under the lead apron and the other exposed on the physician's left arm.

Results. — A non-significant trend towards lower left-arm operator exposure was noted in the extension tube group (28.7 ± 31.0 µSv vs 38.4 ± 44.2 µSv, $p = 0.0739$). No significant difference was noted according to the type of procedure. Radiation levels were low compared with the series published previously and decreased for each operator during the study.

Abbreviations: CA, Coronary angiogram; PCI, Percutaneous coronary intervention.

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1875-2136/$ — see front matter
doi:10.1016/j.acvd.2009.09.006

Conclusion. — The use of an extension tube did not reduce operator radiation exposure during procedures performed through the radial approach. However, physician awareness was increased during the study due to the use of an exposed electronic dosimeter. The use of exposed electronic dosimeters could therefore be recommended to allow operators to improve their protection techniques.

MOTS CLÉS
Coronaires ;
Abord radial ;
Irradiation ;
Dosimètre

Résumé
Introduction. — L'irradiation de l'opérateur est non négligeable en cardiologie interventionnelle. La voie d'abord radiale diminue les complications vasculaires locales, mais augmente l'exposition du praticien. L'irradiation étant inversement proportionnelle à la distance par rapport à la source d'émission, tout moyen de s'éloigner de la source de rayons X devrait diminuer l'exposition.
But. — Démontrer que l'utilisation d'une rallonge entre le cathéter et la rampe de pression permettrait de diminuer l'irradiation de l'opérateur par voie radiale.
Méthodes. — Deux cent trente patients consécutifs ont été inclus et randomisés en deux groupes : avec, et sans cette rallonge. Les mesures d'irradiation étaient réalisées grâce à deux dosimètres électroniques, l'un placé au niveau du thorax sous le tablier de plomb, et l'autre exposé au niveau du bras gauche de l'opérateur.
Résultats. — Aucune différence significative n'est retrouvée entre les deux groupes. Cependant, il existe une tendance de diminution de la dose reçue au niveau du dosimètre exposé pour les examens réalisés avec rallonge : ($28{,}7 \pm 31{,}0$ μSv versus $38{,}4 \pm 44{,}2$ μSv, $p = 0{,}0739$). Les niveaux d'irradiation des opérateurs étaient faibles comparés aux chiffres rapportés dans les études précédentes, et ont diminué pour chaque opérateur au cours de l'étude.
Conclusion. — L'utilisation d'une rallonge entre le cathéter et la rampe de pression n'a pas permis de diminuer l'irradiation de l'opérateur durant les procédures coronaires réalisées par voie radiale. L'utilisation d'un dosimètre électronique exposé a eu comme effet de sensibiliser l'équipe aux problèmes de radioprotection. Ce matériel pourrait être recommandé en pratique courante pour optimiser les pratiques des opérateurs en matière de radioprotection.

Background

Because of an increase in the use of cardiac imaging techniques, there is growing concern about the consequences of radiation exposure, especially for interventional cardiologists [1—3]. Prolonged radiation exposure can induce major and potentially lethal complications [4]. Therefore, the use of X-rays is highly regulated and effective techniques to reduce cumulative doses for the patient and the operator have been described [5]. The use of the radial approach seems to increase operator exposure compared with the femoral approach, even when optimal protection techniques and devices are used [6,7]. However, the radial approach decreases hospital stay and vascular complication rate, and increases patient comfort [8,9]. It is therefore the preferred approach in many interventional cardiology centres in Europe. Operator exposure can be reduced by increasing the distance from the radiation source (inverse-square law). A simple way to increase the distance is to connect a 30 cm extension tube between the proximal part of the coronary catheter and the injection device (Fig. 1). We therefore performed a randomized trial to compare operator radiation exposure during coronary procedures performed through the left radial approach, with and without the use of an extension tube.

Methods

Operators used left-arm and thoracic electronic personal dosimeters (model: DMC 2000 MGP). The thoracic dosimeter was placed under the lead apron and the left-arm dosimeter was placed outside of the personal protection. The left-arm dosimeter reflects brain exposure [6,7,10]. Protection of operators was ensured using a lead apron, low leaded flaps and leaded glass (0.5 mm leaded equivalent for each) in all procedures (Fig. 2).

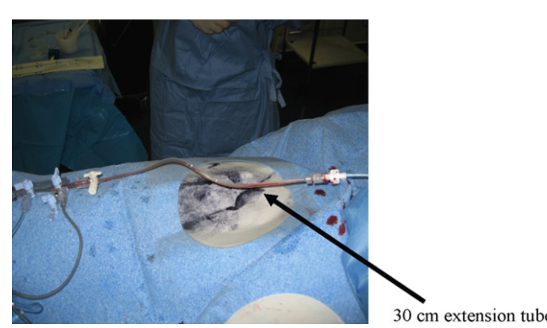

Figure 1. The extension tube.

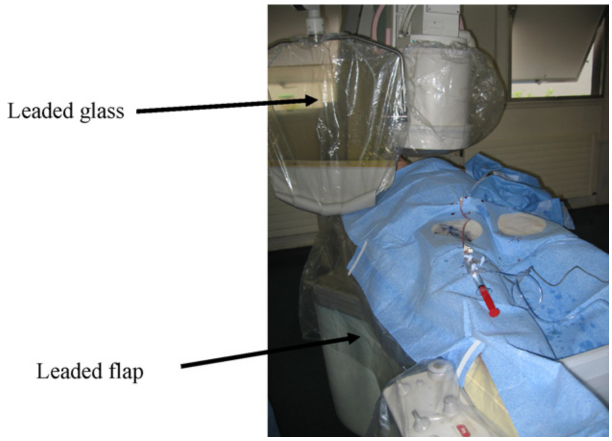

Figure 2. Operator radiation protection devices.

Age, patient weight, body surface, procedure duration, patient radiation exposure and procedural complications were gathered prospectively and entered into a database.

CAs followed by ad hoc PCIs were performed using an eight-year-old digital single-plane cineangiography unit (Integris 5000, Phillips Medical Systems, The Netherlands) A film speed of 12.5 frame/s was selected. All procedures were carried out with respect to current guidelines using 5F or 6F catheters. CAs were recorded using a 17 cm field. Two left ventriculograms were performed on a routine basis using a 23 cm field. Medium contrast was injected manually using a 10 mL syringe without specific assistance injection devices.

Patients were randomized according to their year of birth (even or odd). In patients with an odd year of birth, the procedure was performed using an extension tube between the catheter and the injection device.

All patients, including those undergoing emergency procedures, were screened. Exclusion criteria were limited to history of coronary artery bypass surgery and to procedures performed through the femoral approach. Before collecting the data, informed consent was obtained from the patients.

Statistical analysis

We hypothesized that the use of an extension tube would allow the operator to perform a radial procedure at a distance similar to that for a femoral procedure. In previous studies, the level of radiation exposure by the radial approach was 25—50% higher than with the femoral approach [6,7,11]. In order to detect a 35% relative reduction in operator exposure with a unilateral α value of 0.05 and a β value of 0.1, 110 patients had to be enrolled into each group.

Data are expressed as means ± standard deviations for continuous variables and numbers and percentages for categorical variables. Data in both groups (with and without extension tube) were compared using Student's t-test for comparisons of normally distributed continuous variables, and the chi-square or Fisher's exact test for differences in frequency, as appropriate. A p-value < 0.05 was considered to be statistically significant. STATA statistical software, version 9.2 (StataCorp LP, College Station, TX, USA) was used for all data analysis.

Results

A total of 230 patients were included between 1 January and 30 March 2008. Procedures were performed by five operators with extensive experience in the radial approach (over 1000 procedures). A CA was performed in 141 patients and a methyergonovine provocation test was performed in 36 patients with normal coronary arteries. PCI was performed in 53 patients. Baseline clinical characteristics were similar between groups (Table 1).

There was no difference between groups in thoracic operator radiation exposure measured under the lead apron, with surprisingly low doses (0.00019 ± 0.6 mSv with extension tube and 0.00029 ± 0.54 mSv without extension tube). There was a trend towards lower left-arm operator exposure in the extension tube group when all the procedures were analysed (with vs without extension tube: 28.7 ± 31.0 μSv vs 38.4 ± 44.2 μSv, $p = 0.0739$). No significant difference was noted according to the type of procedure (CA, CA with provocation test, PCI).

Patient radiation exposure was similar between groups in patients with CA with provocation test (with vs without extension tube: 56.5 ± 30.6 Gy/cm^2 vs 57.7 ± 31.7 Gy/cm^2, $p = 0.815$) and without provocation test (with vs without extension tube: 63.9 ± 35.7 Gy/cm^2 vs 60.3 ± 32.9 Gy/cm^2, $p = 0.751$). In contrast, patient radiation exposure was significantly lower during PCI procedures in the group with the extension tube (with vs without extension tube: 72.6 ± 40.7 Gy/cm^2 vs 115.9 ± 69.8 Gy/cm^2, $p = 0.015$).

Fluoroscopic time was similar between groups when CAs were performed with provocation test (with vs without extension tube: 5.2 ± 3.9 min vs 4.6 ± 2.5 min, $p = 0.277$) or without provocation test (with vs without extension tube: 6.3 ± 2.5 min vs 5.2 ± 2.0 min, $p = 0.158$). When PCI was performed, fluoroscopic time was significantly lower in the group with the extension tube (with vs without extension tube: 7.3 ± 4.2 min vs 11.5 ± 8.2 min, $p = 0.037$) (Table 2).

Three operators performed most (75%) of the procedures. No significant difference was found in operator radiation exposure (operator 1: 52 procedures, 33.8 μSv; operator 2: 65 procedures, 29.7 μSv; operator 3: 57 procedures, 35.9 μSv).

There were no major complications. Air embolism with no sequella occurred during one procedure in the group without the extension tube and during three procedures in the group with the extension tube.

Discussion

In this study, the use of an extension tube during coronary interventions did not reduce operator radiation exposure significantly.

Ionizing radiation at high doses (i.e., 1—10 Gy) is not associated with most CAs and/or PCIs. However, high patient radiation exposure has been described during complex PCIs, such as chronic total occlusion. The deterministic effects are predictable and range from blood and chromosome aberra-

Table 1 Demographic and interventional characteristics.

	No extension ($n = 121$)	Extension ($n = 109$)	p
Demographic characteristics			
Men	82 (67.8)	79 (72.5)	0.565
Age (years)	62.5 ± 12.1	63.0 ± 11.2	0.704
Weight (kg)	76.3 ± 15.3	75.1 ± 14.2	0.537
Height (cm)	170 ± 10.0	170 ± 10.0	0.925
Body surface area (m^2)	1.87 ± 0.19	1.86 ± 0.20	0.641
Interventional characteristics			
CA	71 (58.2)	70 (64.8)	0.343
CA with provocation test	18 (14.8)	18 (16.7)	0.719
PCI	33 (27.1)	20 (18.5)	0.158

Data are means ± standard deviations or numbers (%).
CA: coronary angiogram; PCI: percutaneous coronary intervention.

tions to death, depending on the dose and type of radiation exposure. In contrast, chronic low-dose radiation exposure is related to an increased risk of stochastic (random) effects. In this setting, the odds of having any effect are extremely low but unpredictable. To educate operators, training in the use of radiation and radioprotection is mandatory in Europe and the USA [10].

Conflicting data on operator and patient radiation exposure during femoral and radial procedures have been published [12—14]. Lange et al. measured the operator radiation exposure in an experienced single operator and noted a 100% increase when the procedures were performed by the radial compared with the femoral approach (64 ± 55 μSv vs 32 ± 39 μSv, $p < 0.001$ for CAs and 166 ± 188 μSv vs 110 ± 115 μSv, $p < 0.05$ for PCIs, respectively). However, the radiation protection strategy was divergent between both groups, as the upper protective shield flap was used only in femoral cases, whereas it was flipped down in radial cases. Recently, Brasselet et al. performed an operator-blinded registry and compared operator radiation exposure between femoral and radial procedures. Radiation exposure of operators was significantly higher using the radial route compared with the femoral route for both CAs and CAs followed by ad hoc PCIs (29.0 [1.0—195.0] μSv vs 13.0 [1.0—164.0] μSv, $p = 0.0001$ and 69.5 [4.0—531.0] μSv vs 41.0 [2.0—360.0] μSv, $p = 0.018$, respectively). Similarly, radiation exposure of patients was significantly higher using the radial route compared with the femoral route for both CAs and CAs followed by ad hoc PCIs. Moreover, procedural durations and fluoroscopy times were significantly higher with the radial route. Several studies have shown that operator experience of the radial approach is a major factor in reducing procedural and fluoroscopic duration [12,13]. Another factor is the distance between the operator and the radiation source, which is shorter when procedures are performed through the radial artery. As radiation exposure decreases significantly with distance (inverse-square law), we hypothesized that the use of an extension tube would allow the operator to perform a radial procedure at a distance similar to that for a femoral procedure. The benefit of the radial approach for the patient would therefore be achieved without an increase in operator radiation exposure.

Table 2 Operator and patient radiation exposures, and fluoroscopic time.

	No extension ($n = 121$)	Extension ($n = 109$)	p
Operator radiation exposure (μSv)			
All procedures	38.2 ± 44.2	28.7 ± 31.0	0.0739
CA	26.0 ± 27.1	26.6 ± 29.7	0.896
CA with provocation test	70.49 ± 49.6	31.7 ± 38.5	0.350
PCI	50.6 ± 50.4	33.3 ± 28.9	0.168
Patient radiation exposure (Gy/cm^2)			
CA	57.7 ± 31.7	56.5 ± 30.6	0.815
CA with provocation test	60.2 ± 32.9	63.9 ± 35.6	0.751
PCI	115.9 ± 69.8	72.6 ± 40.7	0.015
Fluoroscopic time (min)			
CA	4.6 ± 2.5	5.2 ± 3.9	0.277
CA with provocation test	5.2 ± 2.0	6.3 ± 2.5	0.158
PCI	11.5 ± 8.2	7.3 ± 4.2	0.037

Data are means ± standard deviations.
CA: coronary angiogram; PCI: percutaneous coronary intervention.

We found a trend towards lower operator radiation exposure measured by an electronic dosimeter on the left arm when an extension tube was used (28.7 ± 31.0 μSv vs 38.2 ± 44.2 μSv, $p = 0.0739$), especially during prolonged procedures such as CAs with spasm provocation test (31.6 ± 38.5 μSv vs 70.6 ± 49.6 μSv) or PCIs (29.1 ± 34.6 μSv vs 51 ± 49.8 μSv). However, fluoroscopic time was longer in the PCI group without the extension tube. Furthermore, the operator radiation exposure levels noted in our study were markedly lower than the levels described previously [7]. In fact, the levels noted with the radial approach were similar to those described in previous studies using the femoral approach [7]. Lange et al. [7] reported operator radiation exposure levels during CAs of 64 ± 55 μSv through the radial approach and 32 ± 39 μSv through the femoral approach, compared with 26.3 ± 28.5 μSv in our study. Similarly, operator radiation exposure during PCIs was 166 ± 188 μSv through the radial approach vs 110 ± 115 μSv through the femoral approach, compared with 44.07 ± 44.08 μSv in our study. This may be due to extensive operator experience in the radial approach in our centre (more than 1000 procedures for each operator) and the use of specific protection devices. As operator radiation exposure levels in our study were lower than expected, our study was probably underpowered to detect a difference between groups.

We believe that operator awareness of radiation exposure can be improved markedly by the use of electronic dosimeters placed both under the lead apron and on the left arm. These dosimeters deliver instant information on radiation exposure after the procedure. The operators can therefore improve their techniques to reduce exposure. In our study, a reduction in operator radiation exposure was noted throughout the trial: operator 1, 36.9 μSv during the first month, 26.4 μSv during the following two months; operator 2, 50 μSv and 19 μSv, respectively; operator 3, 39 μSv and 33 μSv, respectively (Fig. 3). If we compare the radiation exposure during the first month of the study and the other two months for the three principal operators, there was a significant reduction in doses: 43.0 ± 38.4 μSv in the first month vs 25.8 ± 25.9 μSv in the other two months ($p = 0.0006$).

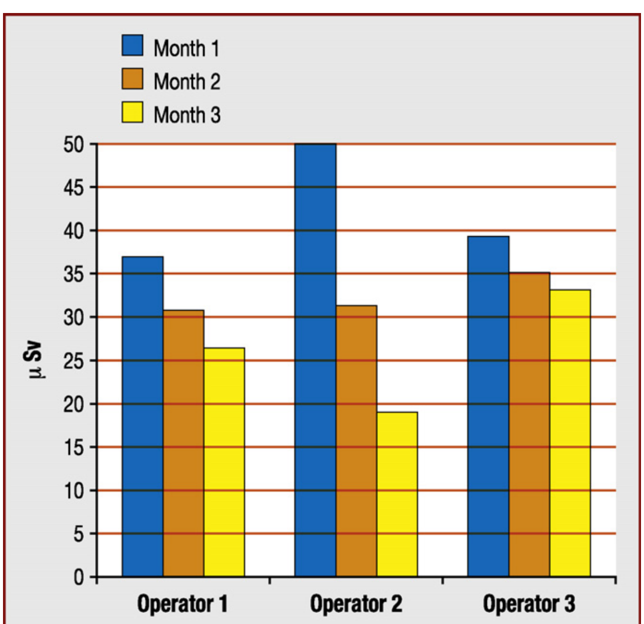

Figure 3. Mean operator radiation exposure during the study.

There are several limitations to our trial. First, the number of patients included was calculated using radiation exposure levels from previous studies. As the levels noted in our study were lower, our study was possibly undersized. Second, the extension tube was only effective during the acquisition of views because the operator had to manipulate the catheter without using the extension tube to place the catheter in the coronary arteries. Third, our results cannot be applied to all operators performing radial procedures, given the experience of our centre in this approach. Fourth, we did not use other devices that reduce operator radiation exposure, such as semiautomatic injection systems, three-dimensional acquisitions or a flat panel.

Conclusion

In this randomized study, we did not demonstrate a reduction in operator radiation exposure with the use of a 30 cm extension tube. We cannot recommend its use in routine practice. However, a trend towards lower levels was shown in prolonged procedures such as PCIs and CAs with provocation test. No complications, such as air embolism, were noted. Operator radiation exposure levels were low compared with previous studies and decreased during the study with operator awareness, due to the use of electronic dosimeters under the lead apron and on the left arm. The use of exposed electronic dosimeters, which deliver instant information on the radiation exposure received during a procedure, could therefore be recommended to allow operators improve their protection techniques. Optimal use of protection devices and improvement of operator technique to reduce patient and operator radiation exposure must gain widespread acceptance by the interventional community and be part of the quality measures of an interventional cardiology programme.

Conflicts of interest

None.

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