Application of mobile X-ray barriers during angiography procedure: how much is it effective? A case study

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Abstract – Introduction: This study intended to assess the effectiveness of application the mobile X-ray barriers (lead-wall) in reducing the radiation dose to interventionists during the brain angiography procedures. Moreover, the radiation dose of patients also evaluated to assess whether the application of lead-wall affects the patient’s dose or not? Material and method: Two interventionists took part in this study. Thermoluminescent dosimeters (TLD-100) were used to monitor the doses to interventionists. 1st-interventionist routinely used lead-wall and 2nd-interventionist didn’t use it. Demographic information of patients and radiation dose information was also recorded. Results: The results of measurements showed that the radiation dose of the 1st-interventionist was 83.57% lower than the 2nd-interventionist (p = 0.04). The amount of dose/min and DAP/min of the 1st-interventionist’s patients were 33.50% and 17.54% less than the 2nd-interventionist’s patients (p = 0.006) and (p = 0.0004). Discussion and conclusion: The results showed that application of lead wall can effectively reduce the occupational dose and it doesn’t lead to increase the patient’s dose.

Keywords: Mobile shield barrier / lead shields / interventional radiology / dose reduction / TLD dosimetry

1 Introduction

Angiography is one of the procedures that can deliver a large amount of radiation dose to patients and physicians. The angiography procedures are more time-consuming in comparison to radiography or computed tomography scan (CT). The fluoroscopy imaging is used for catheter placement and contrast media injection during the procedure which imposes radiation dose to patient and physician who stand near the patient (Zarei et al., 2017; Rasekhi et al., 2017).

There are three important rules to reduce the radiation dose as distance, shielding and time (Bixler et al., 1999; Bevelacqua, 2010). In angiography, the staff cannot increase the distance since they have to be near the patient to perform the procedure. One of the methods that can help them to reduce staff radiation dose by distance is to try to avoid being exposed in the primary beam of radiation, for instance, application of some tools such as sterile tapes to fix the catheters instead of using their hands (Zeinali-Rafsanjani et al., 2017). Since there are many limitations in increasing the distance to reduce the radiation dose, the other two rules can be more important.

Besides of structural shields such as walls, floor and ceiling shielding, there are some other lead or nonleaded shields which can effectively reduce staff’s radiation dose during the procedure such as apron, thyroid shield, gloves, glasses, and mobile X-ray barrier which are known as lead wall in our center (Aghamiri et al., 2011; Kazempour et al., 2015; Tayebi et al., 2017; Saeedimoghadam et al., 2017). Among those, application of apron, glasses, and gloves are more common because their usage is easier, however, lead wall isn’t being used routinely since some interventionists believe that it might interfere the procedure or reduce their speed which might increase both radiologists and patient’s radiation dose due to longer fluoroscopic exposure. As it was pointed, the other protection rule is time, by reducing the time of fluoroscopy the radiation dose of both patient and staff decrease.

This study intended to assess the effectiveness of the application the lead wall by interventionists during the brain angiography procedures. Moreover, the radiation dose of patients also evaluated to assess whether the application of lead wall affects the patient’s dose or not.

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2 Material and method

Two interventionists with the same years of practice took part in this study. One of them routinely and whenever it was possible used lead wall (1st interventionist) and one of them didn’t use it (2nd interventionist). The lead wall had a height of 210 cm and a width of 75 cm and it was equivalent to 2.0 mm lead (Fig. 1). It is worthy to remind that lead wall should be disinfected like the other devices in clean area of angiography room. The interventionists installed a pack consisting of three Thermoluminescent dosimeters (TLD-100) on their thyroid shield and another triple-TLD pack under their apron on the chest before the brain procedures for two months. After a month the TLDs were read, annealed and packed again to be used in the next month. After the second month, the TLD results were read and corrected for operational quantities HP (0.07) and HP (10). The effective dose was calculated using Niklason algorithm as equation (1) (Protection ICoR, 1997; Padovani et al., 2001; Schultz and Zoetelief, 2006; Järvinen et al., 2008):

$$E = 0.02(H_{\text{on}} - H_{\text{under}}) + H_{\text{under}},$$

(1)

$H_{\text{on}}$ and $H_{\text{under}}$ are the personal equivalent dose measured by the TLDs on the thyroid shield and under the apron, respectively.

Demographic information of patients and radiation dose information such as dose area product (DAP (cGy.cm²)), dose (mGy), and fluoroscopic exposure time for each procedure was also recorded. The radiation dose information was provided by the angiography device Siemens, Model No. 3800351.

3 Results

As it was explained in method section, effective dose was calculated using TLD dosimetry on the thyroid shield and under the apron via Niklason algorithm. Mean personal equivalent dose on the thyroid, below the apron, mean effective dose and mean effective dose rate of both interventionists that were accumulated in two months was shown in Table 1. The fluoroscopy parameters that were used by both interventionists were demonstrated in Table 2.

During two months 50 brain procedure were performed by these interventionists. Six patients had some missed information so they were excluded from the study. Twenty-one and twenty-five procedures including 4-vessels, 6-vessels, and brain stent were performed by 1st and 2nd interventionist respectively. Seventeen 4-vessels procedure was performed by the 1st interventionist and 13 by the 2nd interventionists. All brain stent procedures (4 cases) and all 6-vessel procedures (12 cases) were performed by the 1st and 2nd radiologist respectively. Demographic and dose information of patients were shown in Tables 3 and 4 respectively.

4 Discussion and conclusion

Reduction of radiation dose for the angiography staffs and interventionists is very important, since they have to stay in secondary beam of radiation for several minutes, therefore it is very essential for them to reduce their radiation dose as low as reasonably achievable by using appropriate shields and reduce the time of radiation exposure as low as possible (Bevelacqua, 2010).

Some interventionists use most of the equipment that can protect them and the patient. In this study, the effectiveness of mobile X-ray barrier or lead wall application was evaluated during brain angiography procedure.

The results of TLD dosimetry of physicians (Tab. 1) showed that the mean effective dose of the interventionist who used lead wall was significantly lower than the interventionist who didn’t use this protective device ($p=0.04$). The mean effective dose rate of the interventionists was also calculated since their timing of fluoroscopic exposure was significantly different ($p=0.01$). According to Table 1, the mean effective dose rate of the 1st interventionist was 60% less than the 2nd interventionist.

According to Table 2, the mean parameters that were used by the interventionists were not significantly different between both interventionists ($p>0.07$) except the source to patient distances ($p=0.01$ and 0.03).

The thyroid dose was measured by setting the TLD pocket containing 3 TLDs on the thyroid shield, Table 1 showed that the dose on the thyroid shield of the 1st interventionist who used lead wall was 88.16% less than the 2nd interventionist who didn’t use lead wall.

The 4-vessel patients of 1st interventionist weren’t significantly different from the patients of 2nd interventionists in terms of age ($p=0.88$) and BMI ($p=0.29$) (Tab. 3) so that...
these factors could not affect their amount of radiation exposure. Despite of this believe that application of mobile lead wall might provide some discomfort for interventionist and consequently increase the time of fluoroscopic exposure, the results revealed that the exposure time of 1st interventionist who used the lead wall was almost 65.55% less than the 2nd interventionist who didn’t use lead wall in 4-vessel procedure which performed by both of them \((p=0.02)\) (Tab. 4). Accordingly, the amount of dose/min and DAP/min of the 1st interventionist’s patients were 33.50% and 17.54% less than the 2nd interventionist’s patients, therefore, the amount of dose and DAP of the patients were significantly less than the 2nd interventionist’s patients \((p=0.006)\) and \(p=0.0004\).

The 1st interventionist performed 4 cases of brain stent and the 2nd interventionist performed 12 6-vessels procedures. Both groups were not significantly different in terms of age \((p=0.15)\) and BMI \((p=0.55)\) (Tab. 3). Although these groups cannot compare with together considering exposure time, dose and DAP from Table 4 it was revealed that 1st interventionist delivered the fewer amount of dose and DAP to the patients.

Based on Table 2 the parameters that were used by 1st interventionists for placement of brain stent and 2nd interventionist for 6-vessles were not significantly different except the source to patient distance. Therefore, the performance of the interventionists can be compared. Table 4 showed that the time of brain stent procedure by 1st interventionist was fewer than

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Interventionist</th>
<th>Mean kV (p)-value</th>
<th>Mean mA (p)-value</th>
<th>Source to detector distance (mm)</th>
<th>Source to patient distance (mm) (p)-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>4-vessels</td>
<td>1st</td>
<td>71.00 0.07</td>
<td>240.78 0.46</td>
<td>990.43 0.07</td>
<td>741.57 0.01</td>
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<tr>
<td></td>
<td>2nd</td>
<td>76.00</td>
<td>251.00</td>
<td>957.50 0.07</td>
<td>689.00</td>
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<tr>
<td>6-vessels</td>
<td>2nd</td>
<td>72.14 0.67</td>
<td>273.29 0.53</td>
<td>975.00 0.37</td>
<td>742.21 0.03</td>
</tr>
<tr>
<td>Brain Stent</td>
<td>1st</td>
<td>73.50 0.67</td>
<td>337.25 0.53</td>
<td>957.00 0.37</td>
<td>718.33 0.03</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Interventionist</th>
<th>Number</th>
<th>Age ± SD</th>
<th>Height ± SD</th>
<th>Weight ± SD</th>
<th>BMI ± SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>4-Vessels</td>
<td>1st</td>
<td>17</td>
<td>53.17 ± 20.55</td>
<td>164.73 ± 9.12</td>
<td>73.71 ± 13.91</td>
<td>27.69 ± 4.93</td>
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<tr>
<td></td>
<td>2nd</td>
<td>13</td>
<td>51.56 ± 19.85</td>
<td>171.14 ± 5.70</td>
<td>77 ± 12.01</td>
<td>25.84 ± 3.93</td>
</tr>
<tr>
<td>Brain stent</td>
<td>1st</td>
<td>4</td>
<td>82.00 ± 7.48</td>
<td>160.67 ± 2.49</td>
<td>68.33 ± 4.78</td>
<td>26.44 ± 1.44</td>
</tr>
<tr>
<td>6-Vessels</td>
<td>2nd</td>
<td>12</td>
<td>45.43 ± 11.89</td>
<td>167.75 ± 8.98</td>
<td>72.40 ± 14.72</td>
<td>24.77 ± 3.91</td>
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</table>

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Interventionist</th>
<th>Time ± SD (min)</th>
<th>Dose/min ± SD mGy/min</th>
<th>DAP/min ± SD (cGy.cm²)/min</th>
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<tr>
<td>4-Vessels</td>
<td>1st</td>
<td>5.88 ± 2.57</td>
<td>59.26 ± 37.81</td>
<td>858.29 ± 480.52</td>
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<td></td>
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<td>17.07 ± 11.77</td>
<td>89.11 ± 62.41</td>
<td>1040.87 ± 784.61</td>
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<tr>
<td>Brain stent</td>
<td>1st</td>
<td>8.24 ± 3.34</td>
<td>40.59 ± 21.61</td>
<td>477.23 ± 222.14</td>
</tr>
<tr>
<td>6-Vessels</td>
<td>2nd</td>
<td>12.21 ± 5.86</td>
<td>73.60 ± 20.91</td>
<td>991.52 ± 277.98</td>
</tr>
</tbody>
</table>
6-vessels procedure that was conducted by the 2nd one which caused significant reduction of patient’s dose ($p = 0.02$).

It should be noted that the occupational and also patient’s radiation dose was always important for the 1st interventionist and he always tried to reduce the occupational radiation dose by application of suitable shields and the patient radiation dose by reducing the time of fluoroscopy as low as possible. The results showed that using the lead wall could reduce his mean effective dose rate up to 60%, compared to the 2nd interventionist, and 1st showed that using the lead wall doesn’t cause more fluoroscopic exposure of the patient.

However, the meaning of this study is limited by the very low number of practitioners who participated in the study, despite the highly significant differences between the measured radiation doses. In fact, some of the differences observed could be due in part to differences in the technical skills and methods used between the two physicians. It is thus necessary to confirm the results of this case study by a larger study including a higher number of physicians in each group.

Recently, in 2019, Chung et al. showed that a specially designed mobile shield could reduce the staff’s dose to $1/40$ during endoscopic retrograde cholangiopancreatography (ERCP), which was a significant decrease. In this study application of mobile shield barrier reduce 83.5% of staff’s dose which was still a significant reduction. In this study a common mobile shield was used, however, Chung et al. used a specially designed mobile barrier which was dedicated for ERCP (Chung et al., 2019).

Other studies also revealed that the application of mobile shield barrier in long with the other shield devices can reduce the staff’s radiation dose which is in agreement with our results (Heidbuchel et al., 2014; Gilligan et al., 2015; Zeinali-Rafsanjani et al., 2017). Although there are a lot of studies which show that application of all sorts of radiation shields can reduce the radiation dose significantly, there is still some interventionists who resist using some of the shields. Introduction the different radiation shields to them, training how to use them, preparing some protocols for each procedure to use radiation shields and supervising the application of shields by staff according to the protocol by the physicist can reduce the resistance of some staff to use radiation shields whenever it was possible.

**Competing interests**

None declared.

**Funding**

None.

**Ethical approval**

This research was approved by the Faculty Research Ethics Committee of Shiraz University of Medical Sciences with Ethical Approval code of IR.SUMS.REC.1397.113.

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