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A Study to Demonstrate the Significance of the Ceiling Suspension Shield in Minimizing Scattered dose During Cath Lab Procedures

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Abstract

To study the efficacy of the ceiling suspension shield and its importance in the Cath-lab, to minimize the scattered dose to the cardiologist and other personnel involved in Cardiac interventional procedures. The scattered air kerma rate was measured from Siemens Artis dFC/dFA Cath-lab unit using a RaySafe X2 survey sensor and Rw3 slabs Phantom. The scattered dose at the cardiologist's side with various CSS positions was measured. The data was collected using RaySafe view software and evaluated. The reading from different projections with and without CSS and with different angles of CSS was compared. The results show that the scattered dose for AP projection without CSS, with normal position and customized position of CSS was 1.281, 1.069, and 0.934 µSv/min respectively. The dose was reduced by 27% when CSS was placed in an oblique position with the phantom. Similarly, all other commonly used projections with different CSS positions are evaluated for better dose reduction. This study clearly shows that the customized CSS positions helped the reduction of scattered dose by 50% of the open exposure. So we need to take care of the position of CSS according to each view like RAO –CRA, RAO-CAU, LAO-CRA, etc. All these measurements demonstrate that the best strategy to reduce the dosage to the cardiologist and other employees is to keep the CSS in a covered position with flat panel detector during the entire procedure.

Key words - Cath-Lab, Ceiling Suspension Shield, Scattered Dose, Radiation Protection

Introduction

The evolution of X-rays in the medical field was fast expanding and undergoing revolutionary changes in technologies and this improves Cardiac Cath Lab procedures in many respects -(Arramraju et al., 2020). The prolonged radiation exposure in Cath-lab not only increases the dose for the patient(Anna Varghese, Shyamkumar N Keshava, Vinu Moses, George Koshy, Suraj Mammen, Munawwar Ahmed, 2017) but also each member of the team(Wilson-Stewart et al., 2021). The cardiologist and other supporting staff in Cath–lab (Gonza et al..1998) receive a higher level of occupational radiation exposure than in any other radiology cases (Sun et al., 2013). A case study (Roguin et al., 2013) demonstrates the prevalence of brain tumors, particularly left-sided ones, in interventional radiologists. So the safe practice of the usage of ionizing radiation is necessary for all health workers in diagnostic or therapy units because no amount of radiation can be considered safe (Wagner et el., 1994). In the Cath lab, the Ceiling suspension Shield (CSS) is an effective device to reduce the dose to the staff (Fetterly et al., 2011). But it is inevitable to change the position of the CSS according to the position of the X-ray tube, the failure leads to loss of protection. Aim of this study is to check possible positions of CSS for the reduction of scattered dose in cardiac interventional procedure.

Material and Methods

This study was performed in the Siemens Artis dFC/dFA Cath-lab unit. Siemens Artis dFC/dFA unit is a floor-mounted type unit equipped with a 20cm^2 Flat panel detector. The control panel was fitted at the side of the patient couch to select different protocols, frame-rate, Exposure modes, etc(AAPM report no70, 2001). The foot-operated switch is used to expose the machine in Fluoroscopic (Fluoro) mode and Acquisition mode. Monitors suspended on the ceiling are used to view the images and setting parameters during procedures. The scattered air kerma rate was measured using a RaySafe X2 survey sensor with the base unit. The Survey sensor was fixed at 1.5 meters away from the iso-center of the machine. The cardiologist and other supporting staff usually stand in this position during the procedure with all radiation protective accessories (Biso & Vidovich, 2020). The patient entrance reference point (Cousins et al., 2013) is 15 cm below the iso-center towards the X-ray tube. 20 nos, 1 cm thick Rw3 slab Phantom was used to simulate the patient for measuring scattered radiation. Throughout the study, the RaySafe survey sensor was kept at the same point, and the source-to-detector distance was kept at 110 cm. The Ceiling Suspension Shield (CSS) (Fetterly et al., 2011) is a transparent 0.5mm lead equivalence shield suspending on an independent handle very near the Cath-lab unit. CSS is used to protect the cardiologist from the scattered radiation arising from the patient body. It is intended to protect the upper half region of the cardiologist from scattered radiation during the procedure. The normal position of CSS is to keep perpendicular to the patient's long axis.

The most commonly used projections (Di Mario & Sutaria, 2005) in Cath-Lab procedures are Right Anterior Oblique –Cranial (RAO –CRA), Right Anterior Oblique-Caudal(RAO –CAU), Left Anterior Oblique-Cranial (LAO –CRA), Left Anterior Oblique-Caudal (LAO –CAU).Plain LAO, Plain RAO , AP -CRA and AP- CAU.RAO denotes the Flat panel detector(FD) is around 45 degrees toward the right side of the patient, and LAO represents the Flat panel detector is around 45 degrees towards the left side of the patient.CRA (cranial) represents the position of the FD towards the head side and CAU (Caudal) means the FD position is at the foot side. Figure 1 shows the different movement of machine for different projections.

So throughout the procedures, the cardiologist used a combination of these projections for better visualization of the site. The X-ray tube and FD is not at a fixed position during the procedure. So it is necessary to change the position of the CSS concerning different projections because the major part of the scattered beam radiation during procedures was blocked with the CSS . In this study, different projections are used and measured the scattered radiation dose to the cardiologist's side with and without CSS and tried different CSS positions other than the standard set-up to study the further reduction of the scattered dose to the cardiologist (Table -1). The inclusion criteria of projections for this study are the projections used for Angiography and angioplasty procedures. The major projections used in our center are Simple-AP, AP-CRA(0,40), AP-CRA(0,20), AP-CAU(0,40), Plain RAO(40,0), Plain LAO(40,0), RAO -CRA (40,40), RAO -CAU (20,20), LAO-CRA(30,30) and LAO-CAU (40,40).

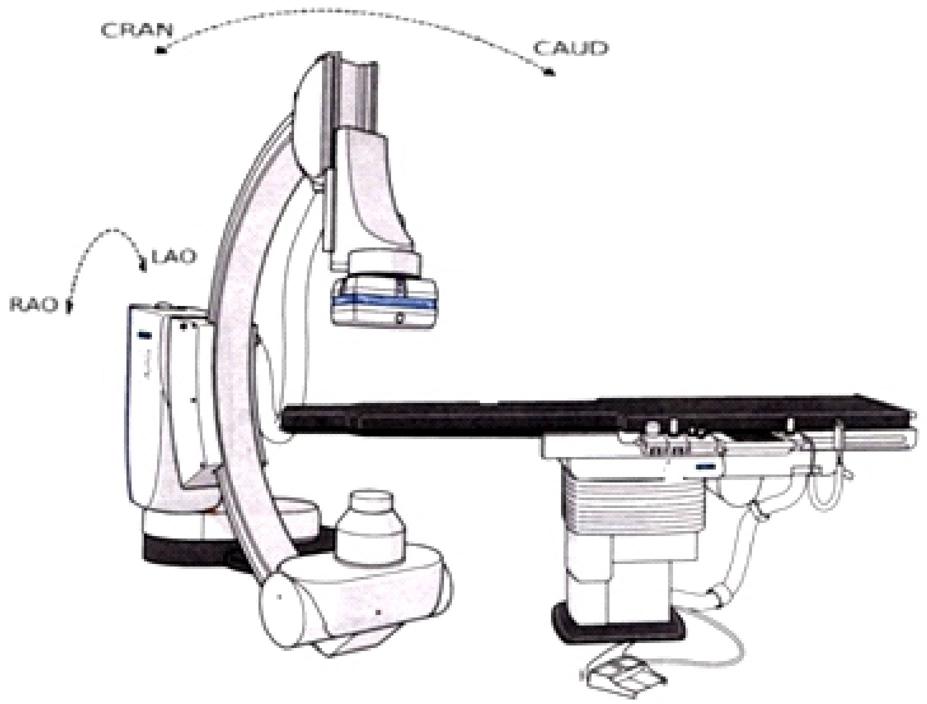
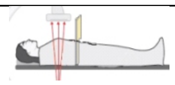
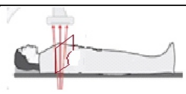
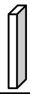
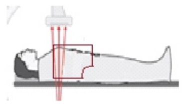
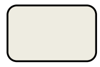
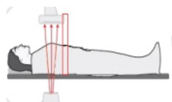
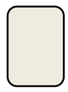


Fig. -1 Cath-lab unit movement for different projections. *Courtesy-Siemens*

Table 1- Different positions of CSS

CSS Position	**Schematic Representation of CSS position**	**Operator View**
CSS 0 – Normal position (perpendicular to the patient)		
CSS 45- Oblique with the patient		
CSS 180- Parallel with the patient		
CSS vertical rotation		

The measurement setup for the Simple AP view is shown in figure -2. Most of the centers used almost similar projections with angles +/- 5-degree variations (Wilson-Stewart et al., 2021). There is no animal or human involved as a sample in this study. The data was collected using Ray Safe View software version 3.3.89 and analysis these data using Microsoft Excel.

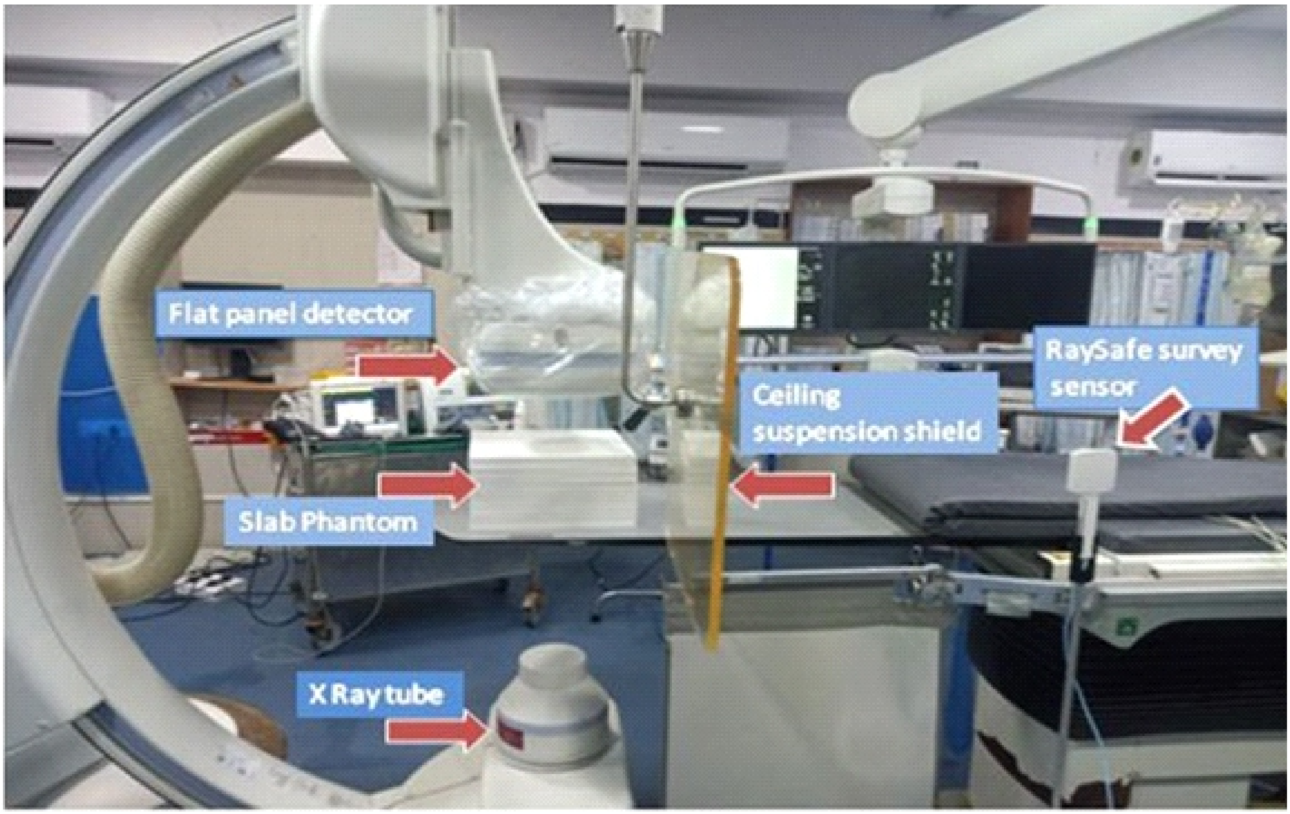


Fig. -2 Measurement set up in Cath-lab for AP view.

Table – 2. Air Kerma rate with different CSS positions in different Cath-lab Projections

Projections	**Air kerma rate in Fluoro mode with different CSS Position.** µSv/min					Suggested position of CSS	Maximum Reduction of Scattered dose w.r.t A (%)
	w/o CSS A	**CSS 0 B**	**CSS 45 C**	**CSS 180 D**	**CSS 90 rotation E**		
AP	1.281	1.069	0.934	NA	NA	C	27.09
AP-CRA (0,40)	7.399	6.937	6.797	NA	NA	C	8.14
AP - CAU (0,40)	4.46	NA	3.976	4.056	2.215	E	49.6
AP -CRA (0,20)	1.97	1.831	1.806	NA	1.858	C	8.32
Plain RAO (40,0)	4.145	3.699	4.063	NA	3.196	E	22.9
Plain LAO (40,0)	4.707	1.945	NA	4.282	NA	B	58.68
RAO-CRA (40,40)	33.1	31.78	30.49	NA	NA	C	7.89
LAO-CRA (30,30)	5.243	2.928	2.421	4.486	2.262	E	56.86
RAO-CAU (20,20)	2.492	2.287	2.223	NA	0.286	E	88.52
LAO-CAU (40,40)	16.17	6.503	6.723	NA	NA	B	59.78

Results

The scattered air kerma rate from commonly used projections was examined with and without CSS. The Air kerma rate from the RaySafe X2 device was noted in each case. The machine operated in Fluoroscopic mode in different projections and various positions of CSS was compared. Table -2 shows the Air kerma rate with different positions of CSS in different tube projections. Some of the position of CSS was not possible or were of no use during certain projection. When the operation mode of the machine changes from Fluoroscopic mode to acquisition mode (Christopoulos et al., 2016), the dose rate changes from 1.281 to 4.21 µSv/min, in AP projection. The scattered doses were evaluated at the operator position with different projections and the maximum values are 33.1 and 16.17 µSv/min for RAO-CRA and LAO-CAU.

Discussion

The results show that the scattered dose without Ceiling Suspension Shield (w/o CSS) was higher by a value of 16.55% from the normal position of the CSS. We have further reduced the dose level in Fluro mode by 27.09% by keeping the CSS in an oblique position for AP Projection. For AP-CRA view the values w/o CSS, CSS 0 and CSS 45 are 7.39, 6.937, and 6.797 µSv/min respectively. In this projection, the oblique position of the CSS can also reduce the scattered dose by around 2% more than the normal position. In the AP-CAU view, CSS positioning with a vertical rotation can help us to reduce the dose by 49.6% and values of the scattered dose reduced from 4.46 and 2.215 µSv/min. This reduction is due to an increase in the vertical coverage of FD with the CSS. Other positions like CSS 45 and CSS 180 can achieve only 10.85% and 9.06% reduction of scattered dose from the null position (w/o CSS). The normal position of CSS ie, CSS 0, is not possible in this view because the FD will come at this position. So CSS vertical is the better position in AP-CAU views. For plane LAO projection, CSS 0 is the best one. It can reduce the scattered dose by ½ from the null position. But for Plane-RAO projections CSS vertical is a better choice; its score is 22.9%, and this position is not possible in Plane-LAO projection. In RAO-CRA, the oblique position of CSS (ie. CSS 45) can reduce the dose by up to 8% from other positions of CSS. While using LAO-CRA projection for better visualization of the left anterior descending artery (LAD) and right coronary artery (RCA), repositioning the CSS with vertical rotation will help to reduce the scattered dose to the cardiologist by 56.86% in Fluro mode exposure. Like RAO- CRA, CSS oblique position is a better choice for RAO-CAU used for the visualization of LCX (Left circumflex). According to the choice of the cardiologist, CSS 0 and CSS 45 can be used for LAO-CAU. Because it will reduces the scattered dose by 59.78% and 58.42%, respectively, from open exposure. When the machine operates in acquisition mode, the scattered dose increases thrice compared with Fluoroscopic mode. The scattered dose at the operator side (cardiologist Position) was evaluated in different projections and found that RAO-CRA and LAO-CAU contribute more dose to the operator compared with other projections (fig-3). The dose with respect to AP projection increases by a factor of 12.62 and 25.84 for LAO-CAU and RAO-CRA respectively.

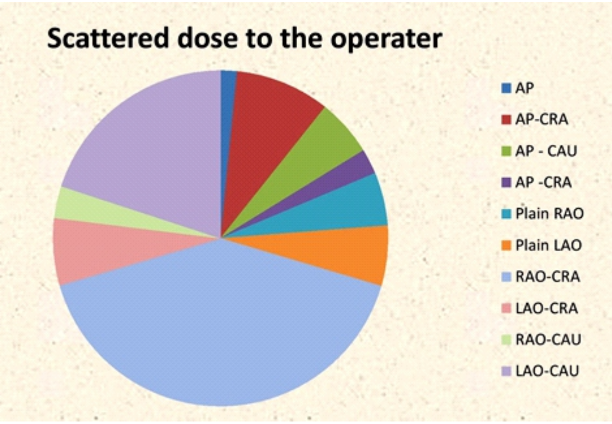


Fig. -3. Scattered dose to the operator in different projections

Limitation of this study

- Single centered study and projections used in this study are commonly employed in our institution.
- Different models of CSS are available in the market, in this study we use only one model which is installed in our Cath lab. So there is a future potential for this study by comparing different CSS models for the best dose reduction.

Conclusion

The busy schedule of the Cath-lab procedures will lead to neglecting the proper usage of some crucial protective devices, one of which is the Ceiling Suspension shield (CSS). This study clearly shows that the CSS helped the reduction of scattered doses to the cardiologist by 50%of the open exposure. But we need to take care of the position of CSS according to each view. Most of the staff was not concerned about the change in position according to different projections. This lost the major radiation protection procedure in Cath-Lab. Therefore we suggest the necessity of using the CSS arrangement according to each projection. The angle of projections used in this study may vary with different centres. So the measurement of the scattered dose in their angle of projection with different CSS positions may be carried out with the help of a Radiation Physicist at the time of commissioning of the machine itself. Also, the results show that in Fluoro mode, the exposure is lesser than in the Acquisition Mode. Therefore, reducing the frequency of the usage of the machine in Acquisition mode helps to reduce the dose to the staff and the patient. Among all commonly used projections, RAO-CRA is contributing more doses to the operator side. So try to reduce the exposure using RAO-CRA view, especially in acquisition mode. The entire study can be used for the radiation protection awareness of cardiologists, interventional radiologists, and other members of staff involved in interventional procedures.

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