EDITORIAL

Radiation Exposure Aspects during Trans-Radial Angiography and Angioplasty

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Ever since the Trans-Radial Approach (TRA) was invented for angiography and angioplasty, there has been concern about whether this technique increases the patient's and operator's radiation exposure compared to the Trans-Femoral Approach (TFA). The importance of this matter is so incredible that it may influence the physician in choosing the approach. This means that despite the clinical advantages of the TRA, including reduction of mortality in patients undergoing primary angioplasty, high safety, reduction of hospitalization time, faster recovery and cost-effectiveness, and less access to site-related bleeding compared to the TFA, the clinician prefers the TFA over the TRA due to the concern about the amount of radiation more than that of the TRA [1-3]. Therefore, it is crucial to evaluate the radiation aspects of TRA.

Determining parameters in the amount of delivery radiation dose include the system type and its settings, the patient's clinical condition and the type of procedure, the behavior and experience of the operator, and the use of a protection device during the process [4, 6].

Although the manufacturers of angiography devices try to have the minimum output radiation dose by maintaining the quality of the image, according to the X-ray tube design, detectors, and the type of reconstruction and their facilities, the amount of radiation is different from one device to another. Regardless of the type of device, setting the following parameters is one of the critical factors in determining the amount of radiation.

Enable Automatic Exposure Control (AEC) during fluoroscopy, radiation field size, and cine-fluoroscopy frame rates [7-9]. It is clear that the automated system is on; the amount of radiation is delivered based on the thickness and density of the tissue. But if the automatic mode is inactive, a trade-off should be made between the dose amount and the image's quality. It should be kept at a minimum in selecting the frame rate, provided that the operator does not mistakenly feel that the patient has bradycardia during the operation. Additionally, the radiation field size during the procedure should be kept to a minimum so that the target vessel, guide wires, and distal catheter or guiding catheters are in the Field Of View (FOV).

In general, Coronary Angiography (CA) delivers less dose than Coronary Artery Bypass Grafts (CABGs), carotid, cerebral, and visceral angiography. In CA, the right and left coronary arteries are examined. The average dose received by the patient due to trans-radial angiography in term Dose Area Product (DAP) varies from 1527 $\mu Gy.m^2$-2190 $\mu Gy.m^2$. As mentioned in the text, it depends on the angiography system, the experience of the operator and the angiography team, the study design, and the anatomical condition of the aorta and coronary vessels. In contrast, in CABGs

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angiography, in addition to coronary arteries, the grafted branches such as saphenous vein grafts, left internal mammary artery, or right internal mammary artery should be examined; the radiation time increases, the dose delivered to the patient, and the operator will increase. In the angiography of carotid, cerebral and visceral vessels, there is a need for the digital subtraction angiography technique because the radiation time and parameters increase, and the radiation dose will also rise over ten folds [10]. In addition, the time of catheter insertion in carotid and cerebral angiography through radial may increase a bit, so the amount given in these types of procedures will increase compared to CA. Compared to CA, Percutaneous Transluminal Coronary Angioplasty (PTCA) requires much manipulation time and, consequently, more radiation time [11]. Because stent placement and expansion of the narrowed vessel with a balloon or balloon placement followed by stenting to open the vessel thoroughly are performed all under X-ray radiation using iodinated contrast agents, this requires a longer irradiation time. Depending on the type, number, and location of coronary artery lesions, PTCA delivers different amounts of radiation. Multiple, Chronic Total Occlusion (CTO), and bifurcation lesions require more time than direct stenting angioplasty. In anomaly ostium vessels, unusual types of the aortic arch, because there is a need to engage and place a catheter in the ostium of the coronary vessels, the time of fluoroscopy radiation increases compared to normal coronary vessels [4, 11]. Regardless of the type of procedure, patients with a higher body mass index, Body Surface Area (BSA), or a thicker body receive a higher radiation dose and produce more scattered X-rays. Therefore, the operator may receive a higher number of X-ray photons. As much as possible, the thickness of the patient's body should be reduced with a band to reduce radiation.

The operator's experience and passing the learning curve in performing angiography procedures are essential in determining the radiation dose. This means an experienced operator will minimize the procedure time and its possible complications compared to a less-experienced operator. The radiation time will be reduced so that the patient will be exposed to radiation in less time. The operator will receive low scattered and leaking photons [12, 13]. There should be a logical relationship between the radiation exposure of the patient and the operator during angiography. But this issue is only sometimes real; in some cases, although the operator is technically professional in performing angiography and PTCA procedures, they may still need to acquire the necessary skill to protect them from radiation or may be indifferent to this issue.

In angiography, the medical physicist must be an active presence in the team and, in addition to the device settings, operator, and staff training, determine the role of all parameters in the received radiation dose and minimize it as much as possible. One of these cases is the installation of the ceiling and bedside shield of the angiography machine and its proper use during the procedure so that the operator receives the lowest dose of radiation. Placing the operator and assistant in the appropriate position and as far away from the patient as possible can prevent them from being exposed to excessive radiation.

The use of new devices and equipment, such as single catheters and guiding catheters, reduces the radiation dose to the patient and the operator to some extent due to the need to not change the catheter and save the time of fluoroscopy radiation. Using a single catheter could reduce the dose imposed on the operator and the patient by 29% and 14% [14]. It is necessary to carefully evaluate the entire length of the studied vessels, especially the coronary vessels. This requires observing them in different cephalic, caudal, and oblique projections using contrast material by the X-ray machine. By presenting and designing appropriate radiation projections as a protocol, our medical physicist can significantly reduce the radiation dose to the patient by 17% by maintaining the image quality compared to other studies [15, 16]. Provided that the AEC system is active, the amount of delivered dose varies at different irradiation angles because the body's thickness changes and the device's radiation parameters change to maintain image quality [16]. In this case, the physicist should calculate or estimate the dose at different angles and remind the operator not to use projections that give a higher amount as much as possible. Applying additional shields has mitigated the radiation dose to the patient, the operator, or both by protecting the breast and pelvic organs among the other tissues [17-19]. In this case, by designing and using such shields with different materials, the medical physicist can first calculate and estimate the dose given to the patient and the operator at various angulation beams on the surface of the phantom. After confirming the results and maintaining the quality of the image, they can evaluate it on the patient. Recently, our team reduced a patient's breast dose by 18-25% using novel composite shields [19].

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