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# COMPARATIVE STUDY ON THE SKIN DOSE MEASUREMENT WITH NANO DOT DOSIMETER WITH MACHINE RADIATION WHILE CARDIAC CATHETERIZATION IN CHILDREN

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**Abstract:**
***Objectives:*** *Skin dose radiation direct measurement in the children with the help of optical stimulation of the luminescence technology through Nano Dot.*
***Materials and Methods***
*The Nano Dot which are (1cm x 1cm x flat plastic cassette) were applied to the skin of the patients with the help of an adhesive tape in the course of cardiac catheterization and skin doses radiation were observed in the time of 24 hours, values of Nano Dot were compared with the available cumulative AK and display and estimation was carried out on a fluoroscopy monitor.*
***Results:*** *In the total sample of 12 patients the range of the age was four months to eighteen years with a median of 1.1 years. Weight was in the range of 5.3 – 86 kilograms with a Nano Dot documented value of 2.58 – 424.8 mGy, range of the cumulative AK was 16.2 – 571.2 mGy. There was a correlation in the AK and Nano Dot values respectively 0.94 and 0.88. The estimation was carried out through International Electro Technical Commission standards.*
***Conclusions:*** *OSL application through Nano Dot gave a substitute for direct measurement of children fluoroscopic skin dose in cardiac catheterization. Research outcomes reflect that children actual skin-dose was 1/3 less than AK estimations in the adult sample collection.*
***KEYWORDS:*** *Cardiac Catheterization, Congenital Heart Disease (CHD), Children, Radiation Measurement and Radiation Dose.*

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## INTRODUCTION:

Radiation dose in the process of medicine has become a concern in the application of X-rays, as it induces malignancy in children. Multiple procedures were carried out on CHD children about catheterization; therefore, exposure chances at an earlier stage of life are high cumulative radiation. Recently, emphasis is given to cardiac catheterization radiation dose and other procedures of cardiac imaging. Numerous strategies of dose reduction are also forwarded for the cardiac catheterization of children. Radiation measuring ability in terms of accuracy is required for the proper use of decision making by the users as the risk factor is two-fold; firstly, skin absorption that causes erythema, necrosis and epilation, less predictable in the threshold cases. Output of the machine decreases due to the thickness of the patient skin; less risk is involved in the small size patients. Secondly, risk is involved in stochastic effects radiation risks, and general in the pediatric patients. Induction of cancer depends on the amount of absorbed radiation as a primary risk which cannot be measured easily [1]. Fluoroscopy is known as a poor radiation measure; numerous estimates are indirectly available such as DAP and AK (more appropriate). According to International Electro Technical Commission (IEC), the reference is (15 cm) from iso center to X-ray tube direction as adopted by all the manufacturers considered reasonable in terms of an average skin sized patient. Few points are neglected in this definition such as variation in body-size, attenuation table, angle of the beam, patient backscatter and AK conversion to kerma tissue. Tube position are not accounted in the additional reduction of the determining effects potentials [2]. DAP calculation is independent of the area of beam and patient as no reference is required; however, influence of AK cannot be eliminated for ideal skin dose calculation. As DAP is the best available marker for stochastic risk as it tells about the radiation amount received by patient. Both DAP and AK have limitations as current available sources of feedback for operating physician. Direct measurement can overcome few of these shortcomings in patients through the determination of radiation exposure and thermos luminescence dosimeters attached with patient. OSL is another method for the measurement of radiation exposure [3]. TLD helps in measuring once through heated film and discharge of trapped energy through observed reading. Objective of our research is the skin dose measurement through OSL dosimeters and comparison of the research outcomes with the conventional measurement of machine for cumulative AK.

## MATERIALS AND METHODS:

Research is an observational prospective research, carried out as a component of improvement of the quality for laboratory cardiac catheterization. Prior permission of the institution was taken before the conduct of this research as research utilized Nano Dot, which is an OSL dosimeter assessment of dose for radiation of single point.

### Nano Dot

Nano Dot is flat, size (10 mm x 10 mm), plastic cassette containing Aluminum oxide filmed coated carbon crystals doped and optically-stimulated luminescence (OSL) dosimetry type as shown in Figure-I. The adjustment of sensitivity was made by manufacturer having 2 percent between barcode, serial number and Nano Dots.

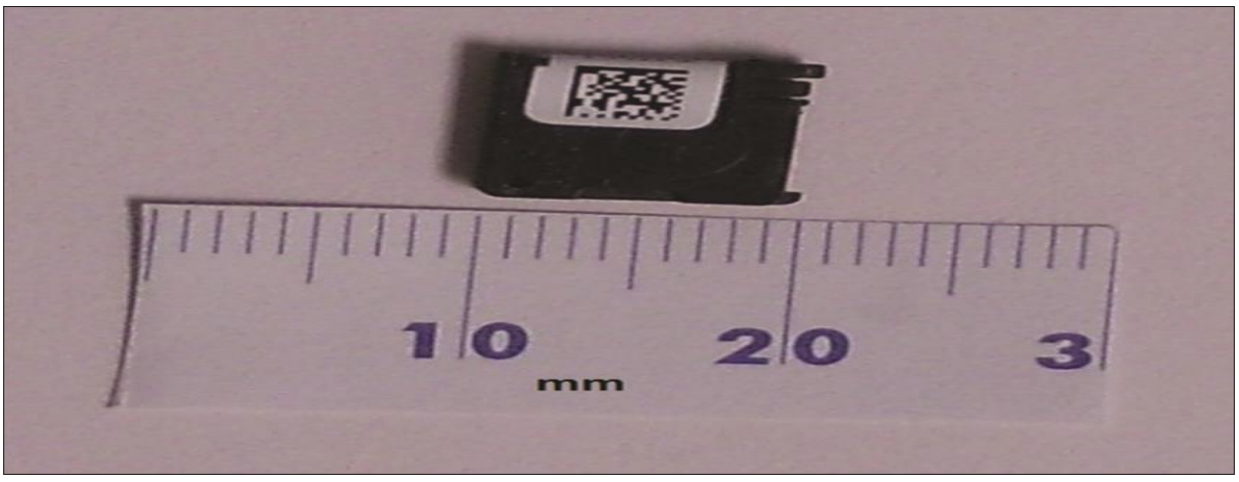


**Figure 1: Nano Dot**

**Nano Dot placement on the patient**

We used 4 Nano Dots, 2 for every plane of fluoroscopy through an adhesive and patients faced the barcode side as the H-Ray tube faces the sensitive crystals. To get the reading of frontal plane these are placed at patient's back to avoid procedural pressure score of spine and lateral plane the position of Nano Dot was right side of chest in the direction of X-ray tube as shown in Figure-II. It was accounted that double exposure should be avoided reading was evident in the first 2 patients and 3rd patients onward a customized radio-opaque thread was attached out of the sensitivity range as they helped in the refinement of the Nano Dots positions for the prevention of double exposure [4]. For characterization procedure Nano Dots were detached for avoidance dissipation and after being sterilized reused.

**Reading Nano Dots**

Calibration was carried out using Micro-star® reader (Land Auer Inc., Glenwood, IL, USA) in triplicate as exposed to 80 kVp in the range of 0 – 1 Gray (0 – 100,000 mrads) with separate barcode identification (sensitivity in the range of 0.05 – 0.85 percent). At the gap of thirty minutes of exposure reading was taken after the achievement of a steady level.

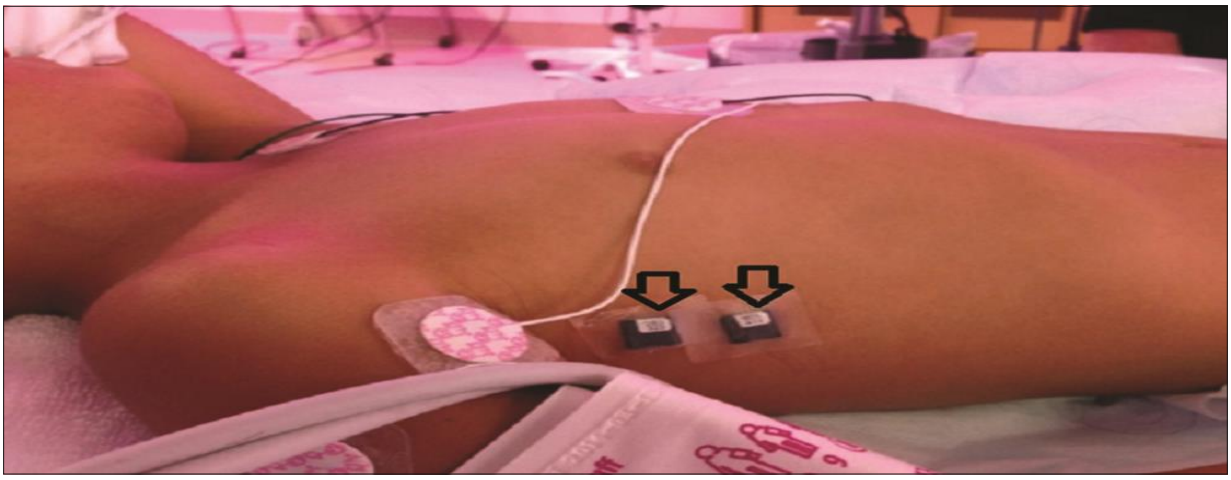

**Figure 2: 02 Nano Dots (arrows) applied on right chest for the measurement of lateral plane radiation**

Every imaging was carried out with 2 Nano Dots and their values were in the range of five percent. Three readings were taken to note average and SD [5]. Three readings given a high concordance as OSL provides an opportunity to use a Nano Dot thrice; whereas, TDL did not. An average was taken after exposure in both lateral and PA planes.

**Patient data**

Diagnosis, body size, demographics and procedure type were taken from the laboratory record and cumulative AK readings from the display of fluoroscopy monitor. Lateral and PA plane AK values were added to form the cumulative AK value. According to the manufacturer provided sheet AK was estimated at reference point in the guidelines of IEC below iso center H-Ray beams (15 cm).

**Statistics**

Readings were presented in median, range and cumulative AK. Plot of the scattering was made in MS Excel. Formula and Linear Regression Trend was used for value correlation. Best-fit trend line was used for correlation coefficient through Sigma Plot V-13 software by SysTest Software's.

**RESULTS:**

Research included 15 patients and dropped 2 patients because of dose reading discrepancy and an adult (22 year) was also excluded. An analysis of twelve cases was made in Table-I. range of the age was four months to eighteen years with a median of 1.1 years. Weight was in the range of 5.3 – 86 kilograms with a Nano Dot documented value of 2.58 – 424.8 mGy, range of the cumulative AK was 16.2 – 571.2 mGy. There was a correlation in the AK and Nano Dot® values respectively 0.94 and 0.88. Cardiac catheterization procedure type included 04 atrial septal defect closures, 02 left and right heart hemodynamic including angiography, 02 balloons pulmonary valvuloplasty, 02 coarctation balloon angioplasty, 01 PDA closure and 01 coronary angiographies. Fluoroscopy time was in the range of 3.3 – 65.2 minutes. On the basis of Nano Dot values, radiation skin doses of children were (65%) as seen on fluoroscopy monitor display.

## DISCUSSION:

Because of several factors the approximate Nano Dot reading was (65%) in interventional reference of cumulative AK observed through fluoroscopy display consistent to the previous estimates of skin dose and AK [2]. As direct measurement in carried out which is important in the cardiac catheterization patients due to variation in the body size [6]. According to the manufacturer provided sheet AK was estimated at reference point in the guidelines of IEC below iso center H-Ray beams (15 cm); whereas, the distance was approx. 6 cm in the case of a six-kilogram baby [7]. Skin surface is not represented through a distance 15 cm of iso center, as it is in the outside mid-air in the case of a small child; furthermore, angular beams are not included in AK measurements, backscatter and table attenuation [8].

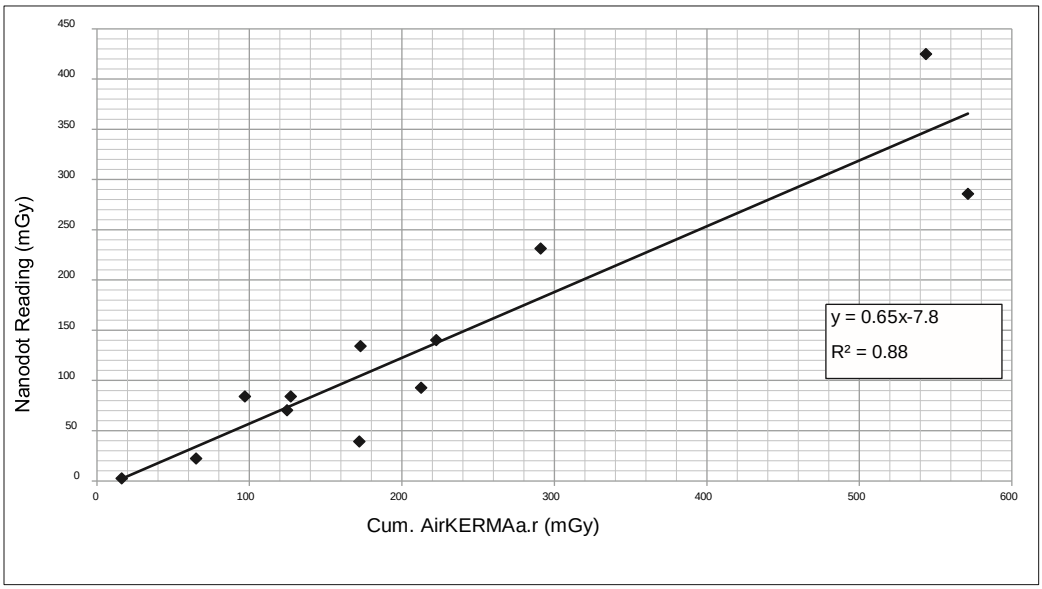


**Figure 3: Association between cumulative air kerma at interventional reference point and Nano dot reading.**

**Table 1: Radiation dose and Demographics parameters for cohort study (*n*=12)**

| Parameter | Range | Median |
|---|---|---|
| **Age in years** | 0.4 - 18 | 1.1 |
| **Body weight in kilograms** | 5.2 - 86 | 8.4 |
| **Fluoroscopy time in minutes** | 3.3 - 65 | 27.9 |
| **Cumulative dose by air kerma in mGy** | 16 - 571 | 172 |
| **Total dose by Nano Dot reading in mGy** | 2.58 - 4248 | 84.1 |

There is an advantage of the cumulative values of AK in terms of a real time display during procedure but the availability of the readings is possible only after the laboratory analysis completion (30 minutes' delay) [9]. Research outcomes are consistently matching with the available research material as conducted by Herron et al. as they targeted the radiation calculation through a formula during cardiac catheterization through average cine mA, fluoroscopy time and exposed frames count [10]. Our research analyzed available facts to associate the values with the AK values as displayed by the manufacturer and also derived a formula for the linear correlation (y = 0.57x + 70) and R2 as (0.84) [11]. According to a Japanese research, radio photo luminescence dosimeter chips were used on fifteen children (on chest) for cardiac catheterization. There was a correlation in the reading of chips and dose variation and DAP respectively

(R=0.82) and (R=0.78) [12]. There was no correlation in the absolute readings because of exposure time interval and dosimeter double exposure precautions.

**Limitations**

Research has few limitations such as Nano Dot was not radio-opaque subject to misplacement. Three patients were excluded initially; issue was resolved by adding smaller thread (radio-opaque) for perfect Nano Dot placement. Small sample size was a limitation of the research, and cost effectively can be obtained by the wide application of this method to make it a standard quality instrument.

## CONCLUSIONS:

OSL application through Nano Dot® gave a substitute for direct measurement of children fluoroscopic skin dose in cardiac catheterization. Research outcomes reflect that children actual skin-dose was 1/3 less than AK estimations in the adult sample collection. There was an association in the reading of nanoDot and cumulative AK.

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