

## Araştırma / Research Article



## Çocuk kliniklerinde çekilen direk radyografların kalitatif değerlendirilmesi

### A qualitative evaluation of direct radiography in pediatric clinics

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#### ÖZET

**Amaç:** Günümüzde radyasyona maruziyetle oluşabilecek riskleri geri döndürebilecek bir yöntem henüz yoktur. Bu nedenle tanı ve tedavi için x ışınları kullanırken "A(s) L(ow) A(s) R(easonably) A(chievable)", yani "mümkün olan en az dozla bu işi başarmak" prensibini kullanmak önemlidir. Çocuk kliniğimizde tanısız amaçlı çekilen direk radyografları bu amaçla kalitatif olarak değerlendirdik. **Materyal ve Metod:** Üniversite hastanemiz çocuk kliniklerinde (poliklinik-servis-yoğun bakım) ocak 2015 başından mart 2015 sonuna kadar muayene edilip tanısız amaçlı direk radyografi çekilen hastalar retrospektif olarak çalışmaya alındı. Hasta listesi otomasyon üzerinden elde edildi. Onüç farklı hekime ait çekim istekleri vardı. Hasta listesine uyan radyoloji görüntüleri PACS (Picture Archiving and Communication System) sistemi üzerinden DICOM formatında klasöre yedeklendi. Elde edilen görüntüler OsiriX adlı açık kaynak yazılım ile işlenerek sınıflandırıldı. Veritabanı sıralandı. Bu veritabanı ikiye ayrılarak iki ayrı radyoloji uzmanınca BASICS (Beam-Dozlama, Artefact-Artefakt, Shielding-Koruma, Immobilization-Sabitlenme, Collimation-Kolimasyon, Structures-Yapıların uygunluğu) prensiplerine göre değerlendirildi. Sonuçlar bilgisayar ortamında istatistiksel olarak yorumlandı. **Bulgular:** Çalışmaya toplam 552 hastadan elde edilen 711 direk radyografi alındı. Hastaların yaş aralıkları bir gün ila 18 yıl aralığında idi. 158 hastaya birden fazla film çekilmişti. Çekilen grafler ağırlıklı olarak Akciğeri görüntüleme amaçlıydı. Bunun yanında ayakta direk batın, Water's, el bilek grafisi gibi muhtelif grafler vardı. 711 çekimin %74 (n=528)'inde KVP değeri vardı. Beam (Dozlama)'in diğer bileşenleri olan Part Thickness(cm), mAs, Time, mAs, SID, IR size, Exposure Indicator (EI) verileri graflerin hiçbirinin metadatasında yoktu. Yüzde beş (n=36) vakada artefact (artefakt) gözlemlendi. Sadece 4 vakada (<%1) shielding (koruma) yapılmıştı. Immobilisation (sabitlenme) oranı %98 (n=698) oranında uygundu. %48(n=342) vakada uygun collimation (kolimasyon) vardı. Diğerleri yetersiz idi. Dijital cropping (kesme) sadece 32 çekimde uygulanmıştı (%4.5). Vakaların %90'ında (n=639) grafide olası gereken structures tamdı, yani grafide görülmesi istenen organlar çekim alanında görünüyordu. **Sonuçlar:** Beam (dozlamaya) ait metadatanın olmadığını görünce çekim senaryolarını izledik. Tüm çekimler öncesi bu değerler giriliyordu. Ancak konunun önemi üretici firmalarca bilinmediğinden veri tabanına kaydedilmediği belirlendi. Bulgular da da görüldüğü gibi BASICS prensiplerinin immobilization dışındaki tüm bileşenleri iyileştirmeye açıktır. Farkındalık oluşması gerekenler çocuk hekimleri başta olmak üzere radyoloji teknisyenleri, radyoloji doktorları ve yöneticilerdir. Konunun çözümü ölçme, değerlendirme, planlama ve uygulamaya olacaktir. Çalışmamızın sonunda, kurumumuzda BASICS eğitim çalışmalarına başlanmıştır.

#### ABSTRACT

**Purpose:** No method exists today that reverses the risks of exposure to radiation. Because of this, it is important to abide by the principle of A(s) L(ow) A(s) R(easonably) A(chievable) when dealing with X-rays in diagnosis and treatment. We made a qualitative evaluation of direct radiography taken for diagnostic purposes in our pediatric clinic. **Materials and Methodology:** The direct radiographs taken for diagnostic purposes from patients presenting at our university hospital's pediatric clinics (polyclinic-service floor-intensive care) over the period from the beginning of January 2015 to the end of March 2015 were retrospectively assessed in the study. A list of patients was obtained from the computer records. Thirteen different physicians had ordered the radiography. The radiological images matching the patient list were filed via PACS (Picture Archiving and Communication System) in the DICOM (Digital Imaging and Communication in Medicine) format. The images obtained were processed and classified with the open-source software OsiriX. The database was subsequently formatted. Dividing the database into two sections, two separate radiologists evaluated it according to the BASICS (Beam, Artifact, Shielding, Immobilization, Collimation, Structures) principles. The results were statistically interpreted in the electronic medium. **Results:** The study made use of 711 direct radiographs obtained from a total of 552 patients. The patients' ages ranged from 1 day to 18 years. More than one imaging had been made for 158 of the patients. A large majority of the radiography had been taken for the purpose of lung imaging. In addition to these, the radiography also included among others, standing direct abdominal radiographs, Waters views, and wrist radiographs. Seventy-four percent (n=528) of 711 of the imaging had kVp values. The metadata for the radiography did not include data for the other components of the beam or dose, namely Part Thickness (cm), mAs, Time, mAs, SID, IR size, Exposure Indicator (EI). Artifacts were observed in five percent (n=36) of the cases. Shielding had been performed in only 4 (<1%) of the cases. The immobilization rate was optimal in 98% (n=698) of the cases. Collimation was optimal in 48% (n=342) of the cases. The other cases were deficient. Digital cropping had been performed in only 32 of the imaging (4.5%). In 90% (n=639) of the cases, all possible structures were complete in the radiography; in other words, the organs that had been aimed at were present. **Conclusions:** We tracked the imaging scenarios of cases in which beam (dosing) metadata were not available. Metadata values were entered prior to all imaging. It was seen however that the values had not been recorded in the database because of the manufacturers' unawareness of the importance of the matter. As can be seen in the study's results, all of the components of the BASICS principles outside of immobilization are open to improvement. Awareness must be raised, particularly in pediatricians, as well as radiology technicians, radiologists and administrators. The matter can be resolved with a program of measuring, evaluating, planning and implementation. The result of our study was that BASICS training began at our institution.

## INTRODUCTION

X-rays have been used in the diagnosis and treatment of diseases ever since their discovery by Wilhelm Conrad Röntgen (1). In the beginning, only direct radiographs were taken. Today, Computed Tomography, angiography and forms of scopy are widely used for diagnostic purposes. Direct radiography is the main X-ray method that is used for diagnosis (2).

The detrimental effects of X-rays have been known from the beginning of their use in diagnosis and treatment. These adverse effects are defined as “deterministic” in the acute stage and “stochastic” in the long term (3). Especially since life expectancy is longer in children, the probability of “stochastic” effects emerging is higher.

No method exists even today that reverses the risks of exposure to radiation (4). The best way of protecting against harmful effects is to determine the right indication. This however is best attained through a program of additional medical training and post-graduate remedial training and through the introduction of clinical guidelines. In setting forth indications, the recommendation is to abide by the principle of A(s) L(ow) A(s) R(easonably) A(chievable) when dealing with X-rays in diagnosis and treatment (5),(6) .

Various initiatives have been developed to achieve ALARA. One of these is the “Image Gently” group that is an alliance to achieve ALARA in the pediatric group of patients (7),(6). The “Image Gently” group has set forth the standards of BASICS to determine common definitions and measurements.

At our pediatric clinic, we tried to evaluate the direct radiographs taken for diagnostic purposes according to the BASICS principles, working with the goal of identifying areas for improvement.

## MATERIALS AND METHOD

Firstly, the approval of our University’s ethics committee was obtained. The direct radiographs taken for diagnostic purposes from patients (7452 patients, 15,710 examinations) presenting at our university hospital’s pediatrics clinics (polyclinic-service floor-intensive care) over the period from the beginning of January 2015 to the end of March 2015 were retrospectively assessed in the study.

A patient list was obtained from the computer records. Thirteen different physicians had submitted radiography orders. The radiological images matching the patient list were filed via PACS (Picture Archiving

and Communication System) in the DICOM (Digital Imaging and Communication in Medicine) format. The images obtained were processed and classified with the open-source software OsiriX (8). The database was formatted. Dividing the database into two sections, two separate radiology specialists evaluated it in terms of the optimization of the BASICS (Beam-Artifact-Shielding-Immobilization, Collimation, Structures) principles.

The Beam (dosing) metadata of the radiographs were reviewed in terms of kVp, Part Thickness (cm), mA, Time mAs, SID, IR size, and Exposure Indicator (EI) data.

Artifacts were defined as unwanted images appearing in the patient’s radiograph.

Shielding was defined as the protection from radiation of the patient’s more sensitive organs, such as the thyroid gland, breasts, gonads and eyes that are in close proximity to the target field, using lead material during the imaging procedure.

Immobilization was defined as fixing the patient’s position during the imaging procedure to prevent image distortion resulting from the patient’s movement.

Collimation was defined as using a special setup to prevent X-rays from beaming outside of the target area during the imaging.

The procedure whereby the resulting image is digitally cut to display collimation was defined as Cropping.

The term Structures referred to the optimal imaging of the entirety of the target tissues or organs in the radiograph.

The results were statistically analyzed on the computer with Microsoft Excel.

## RESULTS

A total of 7,452 pediatric patients were examined 15,710 times over the course of the study.

The study made use of 711 direct radiographs obtained from a total of 552 patients. The patients’ ages ranged from 1 day to 18 years. More than one imaging had been made for 158 of the patients.

The rate of patient imaging was 7.45%.

Most of the radiographs were taken to provide imaging of the thoracic region (Lung X-ray, Telecardiogram, Chest X-ray). In addition to these, the radiography also included among others, standing direct abdominal radiographs, Waters views, and wrist radiographs (Table 1).

**Table 1.** Distribution of radiographs

Lung X-rays	341
Waters Views	75
Telecardiogram	67
Wrist Radiography	61
Standing Direct Abdominal Radiography	34
Chest Radiography	30
Pelvis Radiography	20
Ankle Radiography	19
Knee Radiography	12
Hand Radiography	10
Scoliosis Radiography	8
Lumbar Vertebrae	6
Abdominal X-ray Lying Flat	5
Cranial Radiography	4
Femur radiography	4
Dorsal Vertebrae	4
Elbow Radiography	4
Cervical Vertebrae	3
Arm	2
Thoracic Vertebrae	1
Shoulder	1

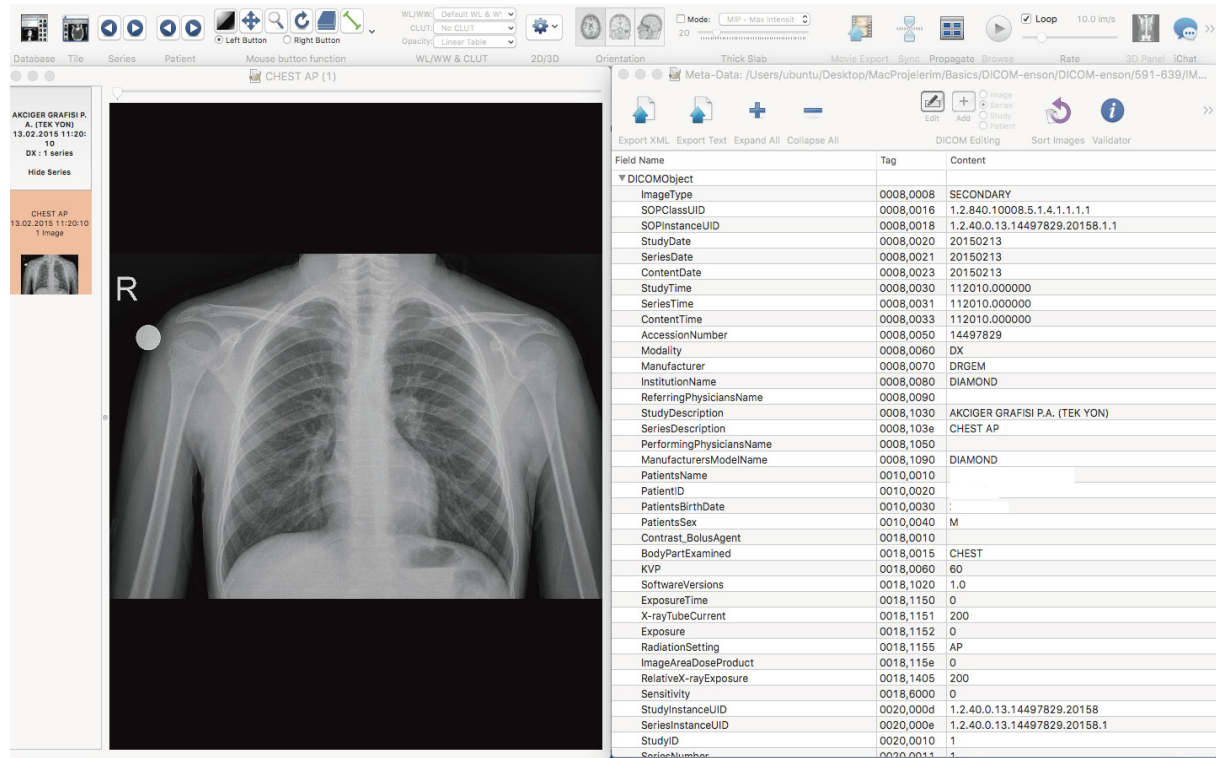
BASICS findings are summarized in Table 2.

**Table 2.** Success rate of radiographs.

Definition	Desired	Number of optimal imaging	Rate of success %
Beam	711	528	74
Artifact	0	36	95
Shielding	711	4	1
Immobilization	711	698	98
Collimation	711	342	48
Structures	711	639	90

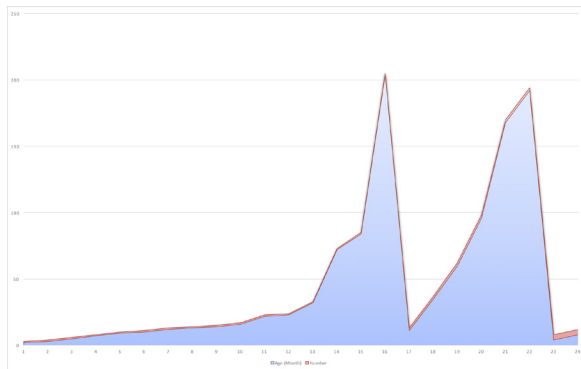
Seventy-four percent (n=528) of the 711 cases of imaging had kVp values. The metadata for the graphs did not include data for the other components of the Beam (dose), namely Part Thickness (cm), mA, Time, mAs, SID, IR size, Exposure Indicator (EI) (Figure 1).

The minimum kVp value entered for the 298 Chest-PA radiographs was 52, maximum was 78, the mean was 63.19. In the telecardiograms, the minimum value for 64 cases was 63, maximum value was 120, the mean was 75.93. The kVp value in the telecardiograms, which was 120, appeared in the pediatric cases of ages 14 months-14 years and all were taken on the same device.

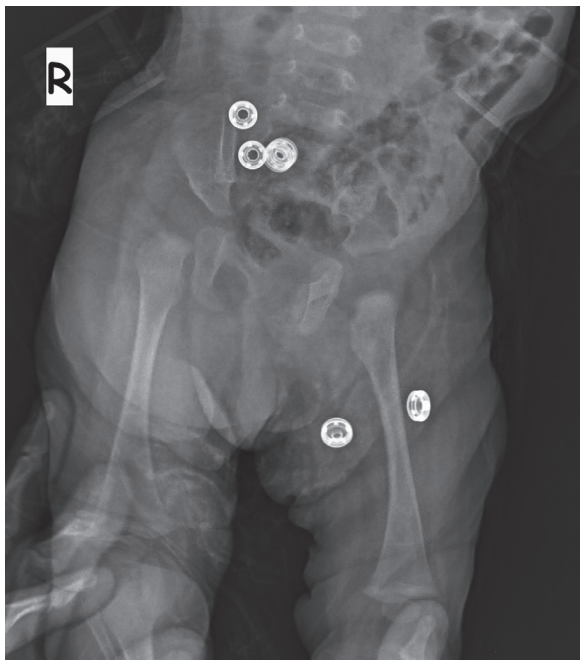


**Figure 1.** Beam metadata

Artifacts were observed in five percent (n=36) of the cases (Figure 3). The number of artifacts was greatest in the Chest-PA radiographs (n=25, 69%); they were also seen in the pelvis radiographs (n=4, 11%), standing direct abdominal radiographs (n=4, 11%), knee radiographs (n=2, 0.6%) and ankle radiographs (n=1, 0.3%). The age of the youngest child whose film revealed artifacts was 2 months, the oldest was 17 years old, and the mean was 3.9 years. Age distribution for the artifacts has been shown in a graph (Figure 2). The objects that generally constituted artifacts were pants buttons, zippers, bodysuit snaps and necklaces.



**Figure 2.** Distribution of artifacts by age



**Figure 3.** Example of artifacts.

The goal of shielding was to protect the gonads, breast tissue, the thyroid and eyes. Shielding had been performed in only 4 (<1%) of the cases (Figure 4).



**Figure 4.** Example of non-optimal gonad shielding.



**Figure 5.** Immobilization. Relative helps to support patient.

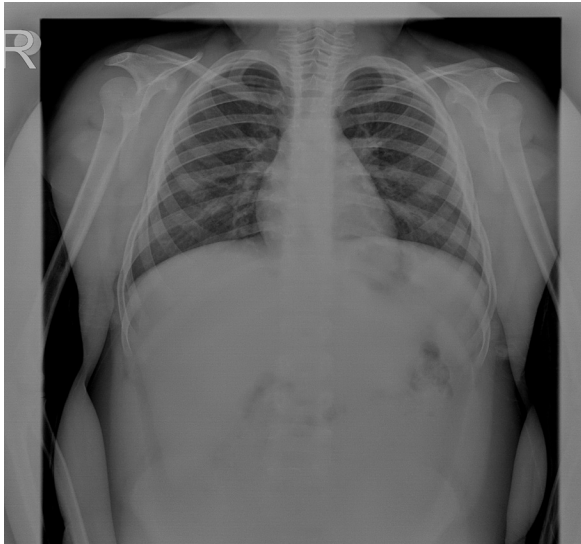
The immobilization rate, at 98% (n=698), was optimal. It was observed that in infants, parents helped in the immobilization and that supporting immobilizing devices were not used (Figure 5). The 3 cases that were unsuccessful were adolescents; all of the others were of the ages 4-35 months. Lung PA and chest films were the most unsuccessful (n=9, 69%). These were followed by Waters views (n=2, 15%), wrist X-rays (n=1) and standing direct abdominal radiographs.

Collimation was optimal in 48% (n=342) of the cases (Figure 6). Deficient collimation was seen mostly in lung PA radiographs (n=294, 80%), which was followed by telecardiograms (n=50, 14%), standing direct abdominal radiographs (n=8, 0.2%), pelvis radiographs (n=7, 0.2%), Waters views (n=2), foot radiographs (n=4) and wrist radiographs (n=1).



**Figure 6.** Appropriate Collimation.

Digital cropping had been performed in only 32 of the films (4.5%). Chest-PA radiographs were the ones that were cropped the most (38%). This was followed by wrist radiographs (n=7, 22%), Waters views (n=5, 16%), pelvis radiographs (n=3, 0.9%), standing direct abdominal radiographs, lateral nasal bone radiographs, and arm radiographs (Figure 7).



**Figure 7.** Arm radiographs

In 90% (n=639) of the cases, the structures were optimal, that is, the desired organs were within the imaging field. Almost all of the deficient films were Chest-PA radiographs (n=27, 93%). Other deficiencies were seen in standing direct abdominal radiographs (n=1) and ankle (n=1) radiographs.

## DISCUSSION

Patient safety involves preventing and protecting the patient from the detrimental effects of any health service that a patient may undergo. Radiation safety is one of the important components of patient safety.

Pediatric Patient safety is even more important. This is because pediatric patients do not have decision-making competence and it is generally their parents who are involved in the process of diagnosis and treatment. Children have a higher risk of exposure to the adverse effects of radiation (6). Calling attention to safety issues with regard to pediatric patients, determining the problems and finding/implementing solutions for these issues are among the basic duties of the physician. This is why it is important to be familiar with the science of patient safety, to learn about the culture of safety, and to determine appropriate strategies.

Pediatricians, radiologists, radiology technicians and administrators need to work together to prevent possible harmful effects associated with radiation (6). This study was initiated as a result of our awareness of our responsibility in this respect.

The principle in general quality culture that “you can’t know if you can’t measure it, and if you don’t know, you can’t manage it” is pertinent here. In our study, therefore, we set out to investigate to see the areas associated with radiation that are open to measurement and improvement. Besides the direct x-ray laboratory, our hospital also houses computed tomography, mammography, scopy and angiography units. We chose to work with direct radiography since evaluation of criteria is simpler and learning the technology is easier, and also because x-rays are the most frequently ordered type of radiography (2).

Most of the radiographs (n=438, 61.6%) were taken of the chest region. This is consistent with the findings of Dorfman et al. (2)

Beam evaluations were technically the most challenging for us. The hospital had 2 different brands of digital x-ray devices, 2 different brands of computed radiography (CR) machines. The metadata of these devices used different nomenclature for the data fields. Among the metadata that we were searching for here, only kVp values were available in all the devices. The rate of recorded kVp values was 74%.

Jurado-Román et al. developed simple protocols to reduce doses by 57% in fluoroscopic laboratories without compromising quality (9).

As an indirect indicator of imaging signals-noise rates and digital imaging quality, the Exposure Indicator is a detector that provides feedback on predictable exposure (7). It is important in achieving ALARA that each hospital determine EI values in their own devices for all imaging fields (10).

With a rate of 1%, shielding was the area in which we were the most unsuccessful. It was observed that

although all the technicians knew how to protect the gonads, this was not done, and further, there was a general lack of knowledge about protecting the eyes, breast and thyroid.

Immobilization, at a rate of 98%, was among the successful areas. Adolescents and children were largely directed through the microphone system in the preliminaries and procedures to follow. The immobilization of infants is achieved with the help of one of the parents or a member of the family. This means that those assisting in the process run the risk of direct or indirect exposure. It was learned that assistive immobilization devices were not being used in the clinics.

Collimation, with an implementation rate of 48%, was observed to be one of the areas open for improvement. Digital cropping was observed in 32 cases. As opposed to its many advantages, digital cropping is a disadvantage of digital imaging since it is regarded as a means of concealing the failure to perform collimation for the sake of convenience and is thus a matter that must be given attention.

It was seen that a 90% rate of success was achieved in terms of structures. Almost all of the deficient films were Chest-PA radiographs (n=27, 93%).

Technicians working in radiology clinics, especially those serving pediatric patients, must have remedial training in this area (11). We observed that implementing the Image Gently (<http://www.imagegently.org>) BASICS principles is an advisable methodology for use in qualitative evaluation and improvement.

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