Contemporary Engineering Sciences, Vol. 19, 2026, no. 1, 7 - 15
HIKARI Ltd, www.m-hikari.com
https://doi.org/10.12988/ces.2026.93168

Optimization of Doses in Conventional Radiology During the Unprepared Abdominal Examination for Children

Ouattara Tofangui Alain[1], Koua Aka Antonin[1], Konate Issa[1], Oka N'Guessan Guy Leopold[2], Dossa Gerald[3] and Gnahore Gbo Firmin[3]

[1] Training and Research Unit in Science, Structure, Matter and Technology
Félix Houphouët-Boigny University, Abidjan, Côte d'Ivoire

[2] Research Institute on New Energies (IREN), Nangui Abrogoua University, Abidjan, Côte d'Ivoire

[3] Polyclinic of Deux Plateaux, Abidjan, Côte d'Ivoire

This article is distributed under the Creative Commons by-nc-nd Attribution License.
Copyright © 2026 Hikari Ltd.

Abstract

The exposure of children to X-rays during radiological examinations is a major public health issue due to their high radiosensitivity. Our study aims to optimize the acquisition protocol of the unprepared abdominal examination (ASP) in pediatrics at the Polyclinic of Deux Plateaux (Abidjan). The methodology was based on a preliminary phase of quality control, followed by a dosimetric evaluation. By applying the ALARA principle, the exposure parameters were adjusted: the voltage was reduced by 12% and the charge by 35%. The results highlight a drastic decrease of 71% in the entrance dose (De) in our study, which dropped from 2.38 mGy to 0.68 mGy. The Dose Area Product (DAP) was also reduced by a factor of 3.5. At the same time, image quality was preserved. This research demonstrates that a rigorous optimization of practices allows for a massive reduction of irradiation in

child patients without compromising diagnostics. It highlights the need to establish national diagnostic reference levels (DRLs) to harmonize pediatric radioprotection in Côte d'Ivoire.

Keywords: Quality control, optimization, DRL, De, DAP

1. Introduction

In Côte d'Ivoire, conventional radiology remains the most accessible diagnostic tool. However, pediatric practice requires particular caution: children have a radiosensitivity higher than that of adults [1] and a longer life expectancy, increasing the risk of long-term stochastic effects [2]. Despite these issues, the country does not yet have national Diagnostic Reference Levels (DRLs), leading to heterogeneity in practices, although research work on DRLs has already been carried out. The Abdominal X-ray Without Preparation (ASP) is frequently prescribed in pediatrics for various digestive pathologies. The aim of our study is to evaluate and optimize the doses delivered during ASP examinations in the conventional radiology department of the Polyclinic of Deux Plateaux in Abidjan. This is done by analytically determining the De and DAP [3, 4] for the examined procedure and the median of each of these dosimetric quantities. The ultimate goal of this work is to present a dose optimization strategy for this specific examination, based on the ALARA(As Low As Reasonably Achievable) principle [5] in order to minimize irradiation of critical abdominal organs in young patients.

2. Materials and Methods

2.1. Materials

Our study was conducted at the Polyclinic of the Two Plateaus (Abidjan) in the radiology department. The radiology device, branded General Electric, consists of a remotely controlled radiology table, equipped with an X-ray tube, a detector (screen-film pair), and a generator operating at high frequency capable of delivering a maximum voltage of 150 kV, as well as an acquisition console to set exposure parameters such as voltage (kV), charge (mAs), and current intensity (mA). Before our study, quality control tests were carried out in this department using the Cobia Flex multimeter and an aluminum filter. The Cobia Flex is equipped with a semiconductor sensor capable of measuring voltage and the half-value layer (HVL).

2.2. Method

In the context of our study, one examination was evaluated: the Plain Abdominal X-ray (ASP). The choice of this examination is based on the highly radiosensitive areas, particularly the gonads and digestive organs [6]. Before any optimization process, the radiological installation was subjected to performance tests. After verifying the compliance of the X-ray tube through quality control tests (checking

the accuracy of the voltage (kV), and the quality of the beam through the half-value layer), we considered 30 ASP examinations [7] with the exposure parameters usually used by the radiologic technologists in order to establish a dosimetric baseline.

These exposure parameters, namely voltage and current, as well as the focus-to-skin distance (FSD), were recorded in a standardized Excel spreadsheet. For the abdominal X-ray (ASP) examination, the irradiation area was 720 cm^2, corresponding to the screen-film pair measuring 24 cm x 30 cm. For each patient, the entrance dose (De) and the dose-area product (DAP) were calculated using formulas (1 and 2), then we determined the patients' median entrance doses (Dem) and the median Dose-Area Products (DAPm). Subsequently, these results were presented to the radiology technologists and radiologists of the P2P radiology department in order to optimize the dose delivered to patients. Together with the radiology department team, we implemented optimization actions which involved modifying exposure parameters such as voltage and current [8], while ensuring that the image quality is not compromised. Then, the study again recorded 60 abdominal X-ray examinations, including 30 examinations with the old exposure parameters called the initial protocol, and 30 other examinations with the new exposure parameters called the optimized protocol. The Dem and DAPm of each protocol were evaluated and compared to each other to verify the impact of the approach.

2.2.1. Calculation of the entrance doses (De) of the patient

The study determined De from the exposure parameters by applying formula (1).

In the absence of knowledge of the constant C, specific to the radiological installation, a standard value for high-frequency generators can be taken as C = 0.1 mGy·m2/mAs [9].

The backscatter factor F is 1.5, taking into account the field size at the entrance surface [10, 11].

De = C * (U/100)^2 * Q * 1/r^2 * F (1)

With:

De: Dose at the patient's entry surface in mGy

C: Local constant characteristic of the radiological facility in mGy·m^2/mAs

U: Voltage in kV

Q: Charge in mAs

r: Focal spot-to-skin distance in m

F: Backscatter factor

2.2.2. Determination of Dose-Area Products (DAP)

The Dose-Area Products (DAP) were determined using formula (2) based on the calculated entry doses De and the irradiation area S, expressed in cm^2.

Since patient backscatter is not included in the DAP, the associated correction is applied.

DAP = (De x S) / BSF (2)

3. Results

3.1. Control of the applied tube voltage and radiation quality

Accuracy tests revealed a voltage deviation of less than 1% and a Half-Value Layer (HVL) of 2.998 mmAl at 70 kV, confirming the stability and adequate filtration of the radiology installation.

3.2. Dose optimization

A total of 60 pediatric patient data for unprepared abdominal exams were analyzed, including 30 exams with the initial protocol and 30 other exams with the optimized protocol. The average value of voltage and charge for each protocol was established. In Table 1, the average values of voltages and charges before and after optimization of the exam assessed in our study are presented.

Table I: Average kV and mAs values before and after optimization

	Protocol initial	**Protocole optimised**	**Ecart**
Voltage(kV)	77,3	68,03	**-12%**
Charges (mAs)	34,37	22,51	**-35%**

Similarly, the median of the distribution of the entrance dose (De) and the Dose-Area Product (DAP) for each protocol was established. In Table 2, the medians of De and DAP before and after optimization of the examination evaluated in our study are presented. We also calculated the difference between the De of the optimized protocol and the De of the initial protocol, then the gain for the DAP, which corresponds to the ratio of the DAP of the initial protocol to the DAP of the optimized protocol.

Table II: Median values of De and DAP before and after optimization

Protocol initial		Protocol optimised	Gap	Gain
De (mGy)	2,38	0,68	**-71%**	
DAP(mGy.cm²)	1316,97	376,32		**3,5**

Figure 1 shows the distribution of entrance doses (De) and Dose-Area Product (DAP) during unprepared abdominal examinations (ASP) in children before and after optimization

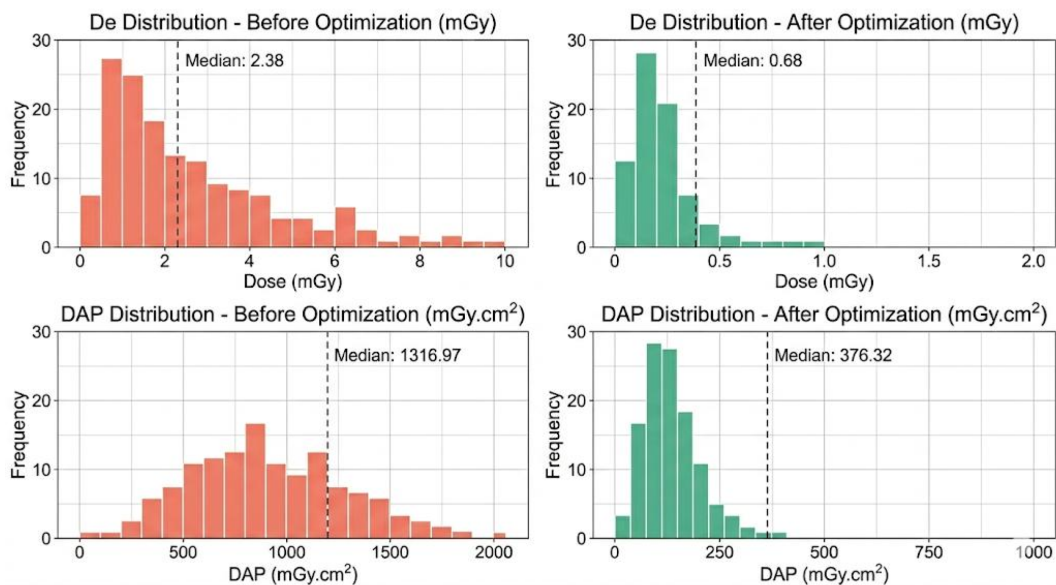

Figure 1: Evolution of the dose distribution at entry (De) and of the Dose-Area Product (DAP) during pediatric abdominal X-ray examinations before and after optimization.

4. Discussion

Pediatric radiology represents a particularly sensitive field, due to the increased radiosensitivity of growing tissues and the longer life expectancy, which increases the risk of long-term stochastic effects [12]. In this context, the gains obtained in our study are particularly remarkable. A 71% reduction in entrance dose was observed for the unprepared abdominal exam (ASP). A dosimetric gain of 3.5 was also observed in the dose-area product (DAP). This reduction in irradiation is all the more crucial since the ASP covers highly radiosensitive areas, notably the

gonads and digestive organs. A fundamental aspect of our study lies in maintaining image quality. This maintenance of diagnostic performance validates our methodological approach: the reduction of the charge from 34.37 mAs to 22.51 mAs did not induce sufficient image noise to obscure essential anatomical details.

It is, however, important to emphasize that this success relies on the stability of the X-ray tube, confirmed by quality control tests. These results align with those reported by Brady et al. (2012) [13], who demonstrate that significant reductions in pediatric doses are possible without compromising diagnosis, provided that the parameters (kV, mAs, field, grid) are adapted to the child's morphology.

In the African context, reference pediatric data are even rarer. However, some countries such as Ghana and Nigeria have initiated steps to establish local pediatric DRLs, often inspired by IAEA work. Exploratory studies in Nigeria report DAPs of up to 1600 mGy·cm² (Aweda et al., 2019) [14]. By comparison, in our study the DAP is 376.32 mGy·cm², which is approximately four times lower than these benchmarks. This performance reflects a true mastery of technical parameters, particularly for abdominal examinations, which are known to be more irradiating. Our results indicate control over dose levels for abdominal X-rays (ASP). Indeed, our study suggests an average DLP of 135.48 mGy·cm² compared to 280 mGy·cm² for the French DRL [15]. The first and most direct implication of our study concerns the reduction of radiological risk for children. By significantly lowering the doses received for unprepared abdominal examinations, our study helps to concretely apply the ALARA (As Low As Reasonably Achievable) principle recommended by the International Commission on Radiological Protection [16]. Ultimately, our study is not satisfied merely with documenting dose reductions; it contributes to the necessary evolution of imaging practices, where scientific progress must imperatively align with an ethic of clinical responsibility.

5. Conclusion

This study showed that optimizing exposure parameters makes it possible to significantly reduce the doses delivered to pediatric patients during plain abdominal X-ray examinations (ASP), with a 71% decrease in entrance dose without compromising diagnostic quality. These results highlight the existence of significant margins for improvement in radiological practices. Adjusting technical parameters (kV and mAs) combined with equipment quality control proved to be an effective lever for enhancing patient radioprotection. In a context characterized by the absence of a diagnostic reference level in pediatrics in Côte d’Ivoire, our study emphasizes the need to harmonize protocols at the national level. It thus paves the way for the implementation of a sustainable dose optimization strategy in conventional radiology, particularly in pediatrics.

Abbreviations

kV: kilovolt

mAs: milliampere-second

De: Entrance Dose

PDS: Dose-Area Product

NRD: Diagnostic Reference Level

mGy: milligray

mGy.cm2: milligray square centimeter

ICRP: International Commission on Radiological Protection

P2P: Polyclinic of the Two Plateaus

Acknowledgements. The authors wish to thank the head of the radiology department of the Polyclinic of the Two Plateaus (P2P). They also thank the Laboratory of Environmental Sciences and Solar Energy of Félix Houphouët-Boigny University, Abidjan, Côte d'Ivoire.

Author Contributions

Ouattara Tofangui Alain: Conceptualization, Writing, Resources

Koua Aka Antonin: Supervision

Konate Issa: Investigation, Methodology

N'guessan Guy Leopold Oka: Formal analysis

Dossa Gerald: Data curation

Gnahore Gbo Firmin: Software

References

[1] International Commission on Radiological Protection (ICRP), Radiological protection in paediatric diagnostic and interventional radiology, ICRP Publication 121, *Ann ICRP*, **42** (2) (2013), 1–63. https://doi.org/10.1016/j.icrp.2012.10.001

[2] National Research Council, Health risks from exposure to low levels of ionizing radiation: BEIR VII Phase 2, Washington DC: National Academies Press; 2006. https://doi.org/10.17226/11340

[3] Salvat C, Jean-Pierre A, Ragot J., Dose optimization in radiology: final report of the OFSP project devoted to diagnostic reference levels in projection radiology (NRDRad project), Switzerland; 2012.

[4] Roth J., *Strahlenschutz in der Medizin*, 1. Aufl., Bern, Verlag Hans Huber 2008, p. 43.

[5] International Commission on Radiological Protection (ICRP), The 2007 recommendations of the International Commission on Radiological Protection, ICRP Publication 103, *Ann ICRP*, **37** (2–4) (2007)1–332.
https://doi.org/10.1016/s0074-27402880013-4

[6] International Atomic Energy Agency (IAEA), Radiation protection and radiological safety in medical applications of ionizing radiation, Safety Guide No. SSG-46, Vienna: IAEA; 2018. https://doi.org/10.1088/1361-6498/ac0498

[7] Aroua A., Vader J.P., Valley J.F.. A survey on exposure by radiodiagnostics in Switzerland in 1998, *Health Phys*., **79** (5) (2000), 600–607.

[8] Etard C., Optimization in radiology: concrete examples. DQPRM, 2010.

[9] Roth J., *Strahlenschutz in der Medizin*. 1st ed. Bern: Verlag Hans Huber, 2008.

[10] Harrison R.M., Backscatter factors for diagnostic radiology (HVL: 1–4 mm Al), *Phys Med Biol*., **27** (11) (1982), 1465–1474.
https://doi.org/10.1088/0031-9155/27/12/005

[11] Harrison R.M., Tissue-air ratios and scatter-air ratios for diagnostic radiology (HVL: 1–4 mm Al), Phys Med Biol., **28** (1) (1983), 1–18.
https://doi.org/10.1088/0031-9155/28/1/001

[12] International Commission on Radiological Protection (ICRP), Radiological protection and safety in medicine, ICRP Publication 135, *Ann ICRP*, **46** (1) (2017), 1–144. https://doi.org/10.1016/s0074-27402880013-4

[13] Brady Z., Ramanauskas F., Cain T.M., Johnston P.N., Assessment of paediatric CT dose indicators for optimisation, *Radiat Prot Dosimetry*, **151** (2) (2012), 241–249. https://doi.org/10.1259/bjr/28015185

[14] Aweda M.A., Adebayo S.B., Adeyemo D.J., Assessment of patient doses in pediatric radiography in Nigeria, *Radiat Prot Dosimetry*, **183** (3) (2019), 321–328.

[15] Institut de Radioprotection et de Sûreté Nucléaire (IRSN), Diagnostic reference levels in radiology and nuclear medicine in France: 2013–2015 review, Report PRP, 2016. https://doi.org/10.1155/2011/574514

[16] International Commission on Radiological Protection (ICRP), Diagnostic reference levels in medical imaging, ICRP Publication 135, *Ann ICRP*, **46** (1) (2017), 1–144. https://doi.org/10.1177/0146645317717209

Received: April 11, 2026; Published: April 30, 2026