MEDISAINS
Jurnal Ilmiah Ilmu - Ilmu Kesehatan

Innovation Article

Development and evaluation of a thoracic immobilization device for pediatric right lateral decubitus chest radiography in dengue hemorrhagic fever

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ARTICLE INFORMATION

Received: September 12, 2025
Revised: November 14, 2025
Accepted: November 21, 2025

KEYWORDS

Thoracic Wall; Severe Dengue; Pleural Effusion; Radiography, Thoracic

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A B S T R A C T

Background: Dengue hemorrhagic fever (DHF) remains a major health concern in hyperendemic regions such as Indonesia. Detecting plasma leakage—often indicated by pleural effusion—is essential for early severity assessment. The right lateral decubitus (RLD) chest X-ray is valuable for this purpose, yet obtaining artifact-free images in children is challenging due to movement and the absence of pediatric-specific immobilization tools.

Purpose: To develop and evaluate a specialized immobilization device for pediatric RLD thoracic radiography to enhance image quality in the assessment of pleural effusion in suspected DHF cases.

Methods: This research and development study was conducted at a regional hospital in Jepara, Indonesia, from April to July 2025. The study included device design, expert validation, prototype refinement, and clinical performance evaluation using radiographer questionnaires.

Results: The device demonstrated high usability, with mean scores of 4.8 for flexibility, 4.7 for patient comfort, and 4.73 for ease of use. Importantly, its application produced RLD radiographs free of motion artifacts, enabling clearer visualization of pleural effusion.

Conclusion: The developed immobilization device effectively supports pediatric RLD chest radiography by improving positioning stability and eliminating motion artifacts. It has strong potential for routine clinical use in DHF assessment and may enhance diagnostic accuracy related to pleural effusion.

INTRODUCTION

Right lateral decubitus (RLD) chest radiography plays a critical role in diagnosing and assessing the severity of dengue hemorrhagic fever (DHF) in pediatric patients, particularly for identifying pleural effusion as a marker of plasma leakage.[1] The Pleural Effusion Index (PEI), calculated from RLD radiographs, is widely recognized as an important predictor of DHF severity and a significant mortality risk factor in dengue shock syndrome (DSS).[2] Despite its clinical importance, acquiring high-quality RLD images in children remains a persistent challenge.[3–7]

The difficulty predominantly arises from the behavioral characteristics of pediatric patients, who are more likely to be uncooperative, anxious, or unable to maintain the required position during the procedure. Even minor involuntary movements can lead to motion-blur artifacts that compromise image clarity and negatively affect the accuracy of PEI measurements.[8] In many clinical settings, immobilization practices still rely on conventional techniques such as straps, sandbags, or direct physical support from staff or parents. These approaches present several limitations: they may cause discomfort and heighten anxiety, expose accompanying adults to unnecessary scatter radiation, and often produce inconsistent stabilization results that increase the likelihood of repeat examinations.[9,10]

Previous research has explored the development of immobilization devices for pediatric radiography.[11–13]

https://doi.org/10.30595/medisains.v23i3.28159
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However, most existing devices are engineered for supine or standard chest projections such as anteroposterior (AP) and posteroanterior (PA) views.[14–17] In contrast, RLD projection—a position that requires children to lie laterally and maintain stability for several minutes—has received limited attention.[18–20] The absence of devices specifically designed to support pediatric RLD imaging highlights a critical gap in current radiographic practice.

In response to this gap, the present study aims to design and evaluate a thoracic immobilization device specifically tailored for RLD examinations in pediatric patients. The device is intended to minimize patient movement, enhance comfort, reduce unnecessary repeat exposures, and ultimately improve the reliability of RLD image acquisition for accurate PEI assessment in DHF management.

METHOD

Study Design

This study employed a research and development (R&D) approach consisting of two major phases: (1) product design and development, and (2) product testing.[21] The R&D framework was selected to ensure a structured process of conceptualization, validation, and empirical evaluation of the immobilization device.

Product Design and Development

Literature Review

The initial step involved a comprehensive review of scientific literature related to pediatric immobilization devices used in radiographic examinations. This review included studies on immobilization tools constructed from materials such as acrylic for lumbar examinations and devices with iron frames and padded supports for abdominal imaging.[22,23] The findings served as foundational references for conceptualizing the RLD-specific immobilization device.

Design Creation

Preliminary sketches of the device were produced manually and subsequently translated into detailed digital models using AutoCAD software. The design aimed to accommodate pediatric body dimensions and ensure stability during the RLD projection.

Design Validation

The digital design was reviewed by three senior radiographers with clinical expertise in pediatric chest radiography. Their evaluation focused on functional suitability, patient safety, ergonomic feasibility, and compatibility with standard radiographic equipment.[24] Feedback obtained from this validation stage was used to refine the final design.

Product Development

Following expert feedback, the device prototype was constructed using materials selected for durability, patient comfort, and radiographic compatibility. This prototype underwent iterative adjustments until it met the predefined functional criteria.

Product Testing

Research Design

A post-test only design with randomized sampling was used to evaluate the prototype's performance in a clinical setting.

Setting, Population, and Sample

Prototype testing was conducted at the Jepara Regional Hospital in 2025. The study population consisted of pediatric patients undergoing RLD chest radiography for suspected dengue hemorrhagic fever. The sample included five radiographers and ten pediatric patients recruited between April and July 2025.[25] Participants meeting clinical indications for RLD imaging and able to safely use the device were included.

Procedure

The immobilization device was used during RLD chest radiography in the participating patients. Radiographers evaluated the device based on patient comfort, stability during positioning, and ease of use. Image quality was assessed to determine whether the device minimized motion artifacts during the procedure. Radiographers completed an eight-item questionnaire using a five-point Likert scale (1 = strongly disagree to 5 = strongly agree). Items assessed flexibility, usability, patient comfort, and overall effectiveness of the device during clinical application.

Data Analysis

Quantitative responses from the questionnaire were analyzed descriptively. Mean and percentage distributions were calculated to summarize radiographers' evaluations regarding device performance, usability, and patient comfort.

RESULTS

Product Design and Development

The initial product design emphasized portability, patient comfort, and positional stability during RLD chest radiography. The completed immobilization device measured 40 × 80 cm and incorporated a hinge system allowing a fixed 90-degree fold for positioning. Soft, artifact-free materials were used for patient contact surfaces, including a 3 cm foam layer and adjustable straps to secure the thoracic region. The final design and prototype are presented in Figure 1, and its detailed specifications are listed in Table 1. Feedback obtained from the expert validation stage—conducted by three radiographers experienced in pediatric chest radiography—resulted in adjustments to cassette holder dimensions and strap configuration to match common clinical equipment. These refinements improved the device's compatibility with existing radiography workflows and enhanced patient stabilzation during RLD positioning.

Figure 1. Final product design and prototype of the immobilization device.

Table 1. Specifications of the Thoracic Immobilization Device

Component	Description
Cassette holder	Compartment for securing X-ray cassette during RLD examination
Belt strap	Adjustable seatbelt-type strap supporting lateral positioning
Support bar	1.5 cm steel bar providing rigid posterior support
Safety belt	Adjustable buckle system accommodating different pediatric body sizes
Immobilization lock	Iron locking joint allowing a fixed 90° folding angle
Patient mat	Soft foam (3 cm) covered with synthetic fabric for comfort
Carrying handle	Plastic-coated iron handle for portability

Result of Product Testing

Laboratory Testing

Prior to clinical application, preliminary testing was performed in the radiology laboratory using pediatric phantoms to verify stability, strap function, and potential image artifacts (Figure 2). The device demonstrated functional positioning and produced clear images without visible artifacts.

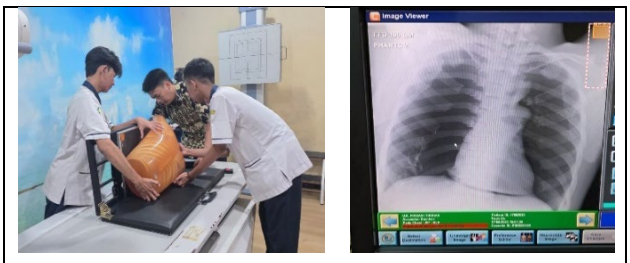

Figure 2. Laboratory testing using pediatric phantom.

Clinical Testing

Clinical evaluation was performed at Jepara Regional Hospital from June to August 2025 involving ten pediatric patients undergoing RLD chest radiography for suspected dengue hemorrhagic fever. One example of the clinical application is shown in Figure 3. Five radiographers assessed device performance using an eight-item Likert-scale questionnaire (1–5). Results are presented in Table 2.

Across all domains—flexibility, comfort, and usability—the immobilization device received high evaluations, with overall mean scores of 4.8 for flexibility, 4.7 for patient comfort, and 4.73 for ease of use. The device was consistently reported to be stable, portable, and compatible with pediatric body dimensions. Radiographers also confirmed that the device did not generate radiographic artifacts, ensuring diagnostic reliability. Minor usability concerns were noted regarding the belt mechanism, which some radiographers reported as slightly difficult to operate. This feedback provides direction for further refinement in future development cycles.

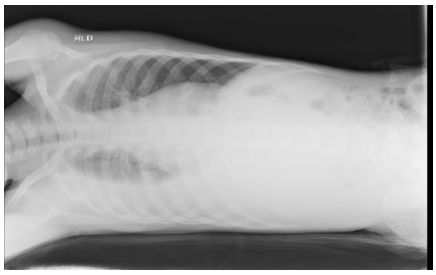

Figure 3. Clinical testing of the immobilization device in pediatric patients.

Table 2. Radiographer Evaluation Scores

Category	R1	R2	R3	R4	R5	Average
Flexibility						
Ease of storage	5	4	5	5	4	4.6
Portability	5	4	5	5	5	4.8
Lock stability (90°)	5	5	5	5	5	5.0
Patient comfort						
Foam comfort	5	4	4	5	5	4.6
Suitability for ages 5–10	5	5	4	5	5	4.8
Ease of use						
Cassette holder performance	5	4	5	5	5	4.8
Belt usability	5	4	4	4	5	4.4
Absence of artifacts	5	5	5	5	5	5.0

DISCUSSION

The thoracic immobilization device developed in this study demonstrated strong usability for stabilizing pediatric patients during RLD chest radiography, particularly in cases of DHF. In clinical practice, chest radiography for DHF commonly includes AP and RLD projections. The AP

projection serves as an initial assessment, while the RLD projection is essential for accurately visualizing pleural effusion—an important indicator of plasma leakage in DHF.[26] When imaging is performed in the supine position, pleural fluid tends to redistribute posteriorly, causing generalized opacification and limiting diagnostic clarity.[27] The ability to maintain a stable lateral decubitus position is therefore crucial to delineate air–fluid interfaces and improve diagnostic accuracy.

The findings of this study show that the immobilization device successfully supported pediatric patients in maintaining the required RLD position. The high mean usability score (4.75) reflects the device's effectiveness in enhancing stability, comfort, and image quality. Radiographs obtained using the device consistently demonstrated a clear air gap in the thoracic cavity, indicating optimal visualization of pleural fluid boundaries. This aligns with the established function of RLD imaging, which enhances detection of pulmonary vascular changes and air–fluid levels that may not be apparent in the AP view.[28]

Compared with previous immobilization tools reported in the literature—primarily designed for left lateral decubitus (LLD) abdominal imaging or oblique lumbar examinations—the present device addresses a unique clinical need.[22,23] Existing devices generally target supine or standard projections, whereas RLD positioning for thoracic evaluation in pediatric DHF has received minimal technological support. The current device therefore represents an important innovation by focusing specifically on pediatric thoracic imaging in the lateral decubitus position.

Material selection was an important aspect of the design process. The combination of a 1.5 cm steel frame and 3 cm foam padding ensured both structural stability and patient comfort. The foam layer helped maintain a neutral, pain-free lateral position in children aged 5–10 years, while the frame accommodated various cassette sizes commonly used in clinical settings.[29] Radiographers also reported that the device did not introduce artifacts, thus supporting its suitability for diagnostic imaging.

Despite its strengths, the device has limitations. Several radiographers noted that the fixation belt was somewhat difficult to operate, reflected in a lower mean score (4.4) compared with other components. This suggests a need for refinement in belt design to enhance ease of use, especially during emergency or high-workload clinical situations. Future development should consider replacing the buckle system with a more ergonomic and rapid-locking mechanism tailored for pediatric handling.

Overall, the findings support the potential of this device to improve positioning accuracy and procedural efficiency in pediatric RLD chest radiography. Its application may reduce motion blur, minimize repeat exposures, and contribute to more reliable assessment of pleural effusion in DHF management.

CONCLUSIONS AND RECOMMENDATION

The pediatric RLD immobilization device developed in this study proved effective in improving positioning stability, patient comfort, and radiographer usability, with high mean scores for flexibility (4.8), comfort (4.7), and ease of use (4.73). The device enabled artifact-free RLD images, supporting accurate assessment of pleural effusion in suspected DHF cases. The device is suitable for routine pediatric chest radiography. Further studies with larger samples and quantitative image metrics (e.g., SNR, CNR) are needed to strengthen its diagnostic validation.

REFERENCES

1. Koo HJ, Lim S, Choe J, Choi SH, Sung H, Do KH. Radiographic and CT features of viral pneumonia. *Radiographics*. 2018;38(3):719-739. https://doi.org/10.1148/rg.2018170048
2. Kusumaningtias A, Hapsari M, Satoto B. Korelasi pleural effusion index jarak interpleura secara ultrasonografi pada demam berdarah dengue anak. *Sari Pediatri*. 2016;16(5):337. https://doi.org/10.14238/sp16.5.2015.337-41
3. Mohd-Zaki AH, Brett J, Ismail E, L'Azou M. Epidemiology of dengue disease in Malaysia (2000-2012): a systematic literature review. *PLoS Negl Trop Dis*. 2014;8(11):e3159. https://doi.org/10.1371/journal.pntd.0003159
4. Wang CC, Wu CC, Liu JW, Lin AS, Liu SF, Chung YH. Chest radiographic presentation in patients with dengue hemorrhagic fever. *Am J Trop Med Hyg*. 2007;77(2):291-296.
5. Lee IK, Liu JW, Yang KD. Clinical and laboratory characteristics and risk factors for fatality in elderly patients with dengue hemorrhagic fever. *Am J Trop Med Hyg*. 2008;79(2):149-153.
6. World Health Organization. Dengue vaccines: WHO position paper—September 2018. *Wkly Epidemiol Rec*. 2018.
7. Tyson ME, Bohl DD, Blickman JG. A randomized controlled trial: child life services in pediatric imaging. *Pediatr Radiol*. 2014;44(11):1426-1432. https://doi.org/10.1007/s00247-014-3005-1
8. Malik MMUD, Majumdar G, Kaushik U, Gupta S. Pediatric imaging: a challenging task in radiography. *Curr Pediatr Res*. 2022;26(9):1627-1632. https://doi.org/10.35841/0971-9032.26.9.1627-1632
9. Lam PK, Ngoc TV, Thu Thuy TT, et al. The value of daily platelet counts for predicting dengue shock syndrome: results from a prospective observational study of 2301 Vietnamese children. *J Infect*. 2021;83(2):167-175. https://doi.org/10.1016/j.jinf.2021.06.004
10. Kaagaard MD, Matos LO, Evangelista MVP, et al. Frequency of pleural effusion in dengue patients by severity, age, and imaging modality: a systematic review and meta-analysis. *BMC Infect Dis*. 2023;23(1):327. https://doi.org/10.1186/s12879-023-08311-y
11. Oliveira M, Silva L, Costa R, Almeida R. Development and validation of a 3D-printed immobilizer for pediatric

upper limb radiography. *3D Print Med*. 2022;8(1):5. https://doi.org/10.1186/s41205-022-00132-1
12. Breen M, Young R, Precht H, McEntee M. Radiographers' perspectives on immobilisation and restraint mechanisms in paediatric radiography. *J Med Imaging Radiat Sci*. 2024;55(4):101738. https://doi.org/10.1016/j.jmir.2024.101738
13. Linder JMB. Safety considerations in immobilizing pediatric clients for radiographic procedures. *J Radiol Nurs*. 2017;36(1):55-58. https://doi.org/10.1016/j.jradnu.2016.04.021
14. Fancourt N, Deloria Knoll M, Barger-Kamate B, et al. Standardized interpretation of chest radiographs in cases of pediatric pneumonia from the PERCH study. *Clin Infect Dis*. 2017;64(suppl 3):S253-S261. https://doi.org/10.1093/cid/cix082
15. Maharana MK, Shetty S, Gomes MJ. Pediatric radiography: challenges and remedy. *Jurnal Ilmu Kesehatan*. 2024;1(2):115-120. https://doi.org/10.58222/jurik.v1i2.1394
16. Thukral BB. Problems and preferences in pediatric imaging. *Indian J Radiol Imaging*. 2015;25(4):359-364. https://doi.org/10.4103/0971-3026.169466
17. Discalzi A. Pediatric radiology: advancements, techniques, and challenges in imaging for children. *Imaging Interv Radiol*. 2024;7(2):12. https://doi.org/10.21767/2471-8564.7.2.12
18. Long BW, Rollins JH, Smith BJ. *Merrill's Atlas of Radiographic Positioning and Procedures*. Vol 1. 13th ed. Elsevier; 2016.
19. Lampignano JP, Leslie LE. *Bontrager's Textbook of Radiographic Positioning and Related Anatomy*. 10th ed. Elsevier; 2021.
20. Kjelle E, Chilanga C. The assessment of image quality and diagnostic value in X-ray images: a survey on radiographers' reasons for rejecting images. *Insights Imaging*. 2022;13(1):36. https://doi.org/10.1186/s13244-022-01169-9
21. Bhuiyan N. A framework for successful new product development. *J Ind Eng Manag*. 2011;4(4). https://doi.org/10.3926/jiem.334
22. Masrochah S, Kartikasari Y, Abimanyu B. Rancang bangun alat bantu fiksasi dengan penanda waktu eksposi untuk pemeriksaan radiografi abdomen akut. *Jurnal Imejing Diagnostik (JImeD)*. 2015;1(1):30-35. https://doi.org/10.31983/jimed.v1i1.3151
23. Prastanti AD, Sulistiyadi H, Fatmayanti H. Rancang bangun alat bantu fiksasi pemeriksaan radiografi lumbal oblik. *Jurnal Imejing Diagnostik (JImeD)*. 2024;10(1):51-55. https://doi.org/10.31983/jimed.v10i1.11076
24. Boateng GO, Neilands TB, Frongillo EA, Melgar-Quiñonez HR, Young SL. Best practices for developing and validating scales for health, social, and behavioral research: a primer. *Front Public Health*. 2018;6:149. https://doi.org/10.3389/fpubh.2018.00149
25. Charan J, Biswas T. How to calculate sample size for different study designs in medical research? *Indian J Psychol Med*. 2013;35(2):121-126. https://doi.org/10.4103/0253-7176.116232
26. Khasana UU, Mahanani A, Zen TF. Studi kasus prosedur pemeriksaan radiografi thorax pada kasus dengue haemorrhagic fever (DHF) di instalasi radiologi RS Roemani Muhammadiyah Semarang. *J Innov Res Knowl*. 2025;5(4):4315-4326. https://doi.org/10.53625/jirk.v5i4.11251
27. Hardy M, Boynes S. *Paediatric Radiography*. Wiley-Blackwell; 2003.
28. Arsin AA. *Epidemiologi Demam Berdarah Dengue (DBD) di Indonesia*. Masagena Press; 2013.
29. Iskandar AARR, Salam N, Basra Y. Efektivitas rancang bangun alat fiksasi pada pemeriksaan os femur di instalasi radiologi RSUD H Padjonga Dg Ngalle Takalar. *Lontara J Health Sci Technol*. 2022;1(1):28-37. https://doi.org/10.53861/lontarariset.v1i1.33