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Research Article

An Evaluation of Image Acquisition Techniques, Radiographic Practice, and Technical Quality in Neonatal Chest Radiography

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ABSTRACT

Background: Neonatal chest radiography is a frequently performed diagnostic examination, particularly in preterm infants where anatomical and/or biochemical immaturity impacts on respiratory function. However, the quality of neonatal radiographic images has been criticized internationally and a prevailing concern has been that radiographers (radiologic technologists) fail to appreciate the unique nature of neonatal and infant anatomical proportions. The aim of this study was to undertake a retrospective evaluation of neonatal chest radiography image acquisition techniques against key technical criteria.

Methods: One hundred neonatal chest radiographs, randomly selected from those acquired in 2014, were retrospectively evaluated. Inclusion criteria for radiograph were as follows: anterior-posterior supine; within 30 days of birth; and with all preprocessed collimation boundaries visible. Image evaluation was systematically undertaken using an image assessment tool. To test for statistical significance, Student's *t*-test, χ^2 test, and logistic regression were undertaken.

Results: Only 47% of the radiographs were considered straight in both upper and lower thoraces. The cranial collimation border extended beyond the upper border of the third cervical vertebra in 30% of cases, and the caudal border extended below the lower border of the first lumbar vertebra in 20% of cases, suggesting high possibility of neonatal overirradiation. Upper thorax rotation was significantly associated with head position ($\chi^2 = 10.907$; $P < .001$) as has been stated in many published textbooks internationally, but arm position had no apparent influence on rotation of the upper thorax ($\chi^2 = 5.1260$; $P = .275$). Birth weight was associated with accurate midline centering of central ray (logistic regression; OR = 1.0005; $P = .009$; CI, 1.00139–1.000957) with greater accuracy observed in images of neonates with higher birth weight.

Conclusion: This study has highlighted areas for neonatal chest radiography improvement. Importantly, the findings bring into question commonly advocated radiographic techniques relating to arm positioning and assessment of rotation while confirming the importance of other technical factors. These findings begin the work toward developing the evidence base to underpin neonatal chest radiograph acquisition, but further prospective work and multicenter/multinational data comparison are required to confirm the findings.

RÉSUMÉ

Contexte : La radiographie pulmonaire néonatale est un examen diagnostique fréquemment utilisé, notamment chez les prématurés lorsque l'immaturité anatomique ou biochimique a une incidence sur la fonction respiratoire. La qualité des images radiographiques néonatales a cependant fait l'objet de critiques à l'échelle internationale et une préoccupation récurrente tient au fait que les radiographes (technologues en radiologie) ne reconnaissent pas le caractère unique des proportions anatomiques chez les nouveau-nés et les nourrissons. Le but de cette étude était d'entreprendre une évaluation rétrospective des techniques d'acquisition d'image en radiographie pulmonaire néonatale en regard de critères techniques importants.

Méthodologie : Les auteurs ont procédé à une évaluation rétrospective de 100 radiographies pulmonaires néonatales sélectionnées au hasard parmi toutes celles réalisées en 2014. Les critères d'inclusion portaient sur les modalités d'acquisition: antéropostérieure, en position couchée; moins de 30 jours après la naissance; visibilité de toutes les frontières de collimation prétraitement. L'évaluation des images a été systématiquement effectuée au moyen d'un outil d'évaluation des images. Le test T de Student, le test du chi carré et la régression logistique ont été utilisés pour établir le niveau de signification statistique.

Résultats : 47% seulement des radiographies ont été considérées droites à la fois pour le haut et le bas du thorax. La bordure de

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collimation crânienne allait au-delà de la bordure supérieure de la 3e vertèbre cervicale dans 30% des cas, alors que la bordure caudale allait au-delà de la bordure inférieure de la première vertèbre lombaire dans 20% des cas, suggérant une possibilité élevée de surirradiation néonatale. La rotation de la partie supérieure du thorax était associée de façon significative à la position de la tête ($\chi^2 = 10{,}907$; $P < 0{,}001$), comme cela a été mentionné dans plusieurs ouvrages de référence internationaux, mais la position des bras n'avait pas d'influence apparente sur la rotation de la partie supérieure du thorax ($\chi^2 = 5{,}1260$; $P = 0{,}275$). Le poids à la naissance était associé à un centrage précis du rayon central sur la médiale (régression logistique, OR= 1,0005; P=0,009; CI, 1,00139-1,000957) la plus grande précision étant observée sur les nouveau-nés présentant un poids à la naissance plus élevé.

Conclusion : Cette étude met en lumière des avenues d'amélioration pour la radiographie pulmonaire néonatale et remet en cause certaines techniques couramment favorisées en ce qui a trait au positionnement des bras et à l'évaluation de la rotation, tout en confirmant l'importance d'autres facteurs techniques. Ces constats entreprennent le travail de développement des données probantes nécessaires à l'acquisition des images radiographiques pulmonaires en néonatalité, mais des travaux prospectifs et une comparaison des données entre plusieurs centres et plusieurs pays seront nécessaires pour confirmer ces constats.

Keywords: Chest X-ray; Pediatrics; Image acquisition; Guidelines; Neonatal; Image quality

Introduction

Over the last 20 years, medical advances, combined with an improved socioeconomic environment, have seen neonatal mortality rates in Europe to decrease from 139,000 in 1995 to 60,000 in 2015 [1,2], but gestational prematurity remains the single most important cause of death within the first month of life [3]. Neonatal chest radiography is a frequently performed diagnostic examination [4], particularly in preterm infants where anatomical and/or biochemical immaturity impacts on the synthesis and secretion of surfactant [5]. However, the quality of neonatal radiographic images has been criticized internationally, and a prevailing concern has been that radiographers (radiologic technologists) fail to appreciate the unique nature of neonatal and infant anatomical proportions [6–8], in particular horizontal rib orientation, differences in thoracic height-to-width ratio, and superior position of clavicles when compared with radiographs of older children and adults [7,8].

Radiographers are responsible for acquiring images of sufficient diagnostic quality to answer the clinical question posed at a dose that is As Low As Reasonable Achievable (ALARA) [9]. The high mitotic capacity of children's cells means that exposure to radiation may increase the risk of developing cancer by 2 to 3 times the risk expected for adults receiving the same radiation dose [10–13], and this risk increases further with relative prematurity of the neonate [1,14]. Consequently, due to their small size, unique anatomical proportions, and relative proximity of radiosensitive organs and structures to the primary beam during chest radiography, neonates are a priority group for assuring consistent and high-quality radiographic (image acquisition) practice.

Although a number of research studies examining neonatal radiography dose and image quality have been undertaken, these have been performed from the perspective of the radiologist or medical physicist and have not considered radiographic image acquisition practices [2,4,11,12,14–20]. Furthermore, although published literature identifies factors that radiographers should take into consideration when undertaking neonatal chest radiography (eg, collimation, use of grid, exposure index, technical parameters, and neonatal thickness/weight), published guidance to direct evidence-based best practice in relation to the application of these parameters is limited [4,20]. This is further compounded by inconsistencies and contradictions in advocated approaches within commonly cited radiographic textbooks with regard to centering, collimation boundaries, neonate immobilization and limb positioning, and use of caudal angulation [21–24]. These inconsistencies are likely to be a consequence of the limited high-quality published evidence to support neonatal radiographic practice. Despite this gap in the underpinning evidence base, and lack of international consensus over radiographic technique and measures of technical quality, authors recommend that neonatal radiography be undertaken by radiographers who are well trained in neonatal image acquisition techniques [12,14,16,19,25]. However, without clarity around best radiographic approach, the content of such training will be dependent on local clinical and academic preferences (eg, preferred textbook).

Acknowledging the limitations within the radiographic evidence base, neonatal radiography practice in Europe has by necessity been predominantly based on the 1996 European Commission (EC) [26] guidelines that were developed following international radiological review and consensus on pediatric imaging standards. However, with respect to neonatal chest radiography, these guidelines were formulated following review of only 72 neonatal chest radiographs acquired between 1989 and 1991 using film-based technologies and were developed without any acknowledged radiographer input. Consequently, although some criteria for evaluating the radiographic technical quality of neonatal chest radiographs are stated in the guidelines [26], limited or no guidance on how a radiographer might use these criteria to determine the diagnostic quality or acceptability of an image is provided. Furthermore, no statements of the relative tolerance ranges for image acceptance (ie, the degree of image technical "imperfection" beyond which remedial action [repeat imaging] is required) are provided. As a result, a gap in the evidence base exists with respect to the synergy between technical image quality (ie, radiographic acceptability tolerance)