NORMAL FINDINGS ON CHEST X-RAYS OF NEONATES*

Beatriz Regina Álvares[1], Inês Carmelita Minniti Rodrigues Pereira[1], Severino Aires de Araújo Neto[2], Emerson Taro Inoue Sakuma[3]

Abstract **The purpose of this study is to describe the normal findings of the newborn chest radiography, the criteria utilized for evaluating the quality radiographs and the correct catheter and tube positions, emphasizing the peculiarities inherent to the patient's age. In the neonatal period changes in the fetal circulation contribute to an increase in cardiac size, skin folds and variations in the thymic silhouette may simulate diseases, the evaluation of catheter and tube positions avoids iatrogenic complications, the abdominal gas pattern must be correlated with the patient's age and the presence of the secondary ossifications centers in the upper humerus and scapula is associated with the term newborn, providing a radiological sign for normal skeletal maturation. The knowledge of the peculiarities and normal radiological findings of the newborn chest radiography avoids ambiguous diagnosis, reduces iatrogenic complications and represents a valuable support in the diagnosis and clinical follow-up of these patients.**

Keywords: Newborn; Normal findings; Chest radiography.

Resumo *Achados normais no exame radiológico de tórax do recém-nascido.*

O objetivo deste trabalho é descrever os achados normais na radiografia de tórax do recém-nascido, os critérios usados para avaliar a qualidade técnica do exame, assim como o posicionamento correto de sondas, cânulas e cateteres, enfatizando as especificidades dos achados radiológicos relacionados à faixa etária do paciente. No período neonatal, a imagem cardíaca é mais proeminente em virtude da conversão da circulação fetal, as dobras de pele e as variações da imagem tímica podem simular doenças, a avaliação do posicionamento adequado de sondas e cateteres evita iatrogenias, o padrão gasoso intestinal apresenta mudanças relacionadas ao número de horas de vida do paciente e a presença dos núcleos de ossificação secundários na extremidade proximal dos úmeros e processo coracóide está associada com a idade gestacional a termo do recém-nascido, representando, portanto, um sinal radiológico de desenvolvimento ósseo normal. O conhecimento das particularidades e dos aspectos radiológicos normais no tórax do recém-nascido evita diagnósticos equivocados, reduz as iatrogenias e representa um valioso suporte no diagnóstico e no acompanhamento clínico destes pacientes.

Unitermos: Recém-nascido; Achados normais; Radiografia de tórax.

INTRODUCTION

The chest x-ray is one of the most frequently requested radiological examinations in neonatal intensive care units (ICU), representing an essential tool in the diagnosis of pulmonary diseases in preterm and term neonates. In these patients, the chest x-ray also allows the evaluation of nasogastric probes, endotracheal tubes, arterial and venous umbilical catheters positioning, as well as detection of bone structures and abdominal alterations usually included in chest x-rays of neonates[1–4].

Since the neonatal radiography is essential for the work of the clinician[1], it is important for him/her to have a broad knowledge about singular aspects of this examination, from the examination performance itself to morphological aspects of the neonate chest anatomic structures which are absent in older children and adults.

Aiming at highlighting such specificities, the authors of the present study have made a detailed review of the literature concerned with chest radiological examination in neonates, illustrated with x-ray films from the teaching files of Centro de Atenção Integral à Saúde da Mulher (Caism) Radiology Service at Universidade Estadual de Campinas (Unicamp).

CHEST X-RAY OF NEONATES

The chest x-ray in neonates, especially the preterm ones, should preferably be performed in the neonatal ICU, with a portable x-ray equipment. The radiology technician must wash his/her hands before performing any procedure for each neonate, aiming at reducing the neonatal infections incidence, since newborns usually present poor immunological defense mechanism[5].

In order to reduce the radiation dose for these small patients, only one anteroposterior view of the chest should be taken, since, in most of cases, this is enough to supply the necessary diagnostic information[6].

In the first radiological examination, it is advisable to include abdominal imaging, since this allows a preliminary evaluation of the presence of air in bowel loops and the ruling out of abdominal diseases likely

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* Study developed in the Department of Radiology – Faculty of Medical Sciences of Universidade Estadual de Campinas, Campinas, SP, Brazil.

1. Doctors, Assistant Professors at Faculty of Medical Sciences of Universidade Estadual de Campinas.

2. MD, Assistant at Service of Radiology – Centro de Atenção Integral à Saúde da Mulher, Universidade Estadual de Campinas.

3. MD, Resident for Department of Radiology at Faculty of Medical Sciences of Universidade Estadual de Campinas.

Mailing address: Profa. Dra. Beatriz Regina Álvares. Departamento de Radiologia, FCM/Unicamp, Cidade Universitária "Zeferino Vaz", Barão Geraldo. CP 6111. Campinas, SP, Brazil 13081-970. E-mail: alvaresb@terra.com.br

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to cause respiratory symptoms. In subsequent x-rays, lateral chest and abdomen views only should be included in cases where there is a clinical indication or necessity of evaluating umbilical probes and catheters localization[1,4].

TECHNICAL FACTORS

Chest x-rays of neonates are in compliance the technical standards when they meet the following criteria[1,2,4]:

a) Visualization of dorsal intervertebral spaces through the cardiac silhouette (film density);

b) right hemi-diaphragm at the level of the posterior arc of the eighth rib (satisfactory level of pulmonary aeration);

c) caudal inclination of anterior costal arcs appearing underneath the posterior ones (adequate centralization of the central beam on the thoracic cage);

d) symmetry of bone structures on both sides of the thoracic cage (correct positioning of the neonate);

Main technical problems that may mimic pathological alterations inducing misdiagnosis are the following:

a) X-ray beam underpenetration, reducing the density differences between intrathoracic structures and simulating false pulmonary opacities;

b) pulmonary hypoaeration, resulting in horizontalization of costal arcs, false widening of the cardiothymic silhouette and reduction of the pulmonary transparency, with possibility of, occasionally, simulating pulmonary edema, hemorrhage, atelectasis and pneumonic consolidations;

c) x-ray beam overpenetration, darkening the radiographic film and possibly concealing pulmonary opacities, mainly the most subtle ones, like interstitial opacities of the neonate transitory tachypnea and the reticulogranular infiltrate of the hyaline membrane disease;

d) patient rotation, causing asymmetry of the chest and resulting in a false prominence of the cardiothymic image towards the deviation side;

e) inadequate centralization of the central ray over the neonate's abdomen, causing a lordotic configuration of the thoracic cage characterized by the cephalic orientation of the anterior arcs, and possibly causing widening and distortion of the cardiothymic image.

The knowledge of these criteria utilized for evaluating the technical quality of chest x-ray of neonates results in technically correct x-rays, besides reducing the possibility of misdiagnosis due inadequately performed examinations (Figures 1, 2 and 3).

INTRATHORACIC ANATOMIC STRUCTURES

The neonate chest undergoes significant birth-related changes during the first hours of life, and presents quite distinct aspects in its anatomic structures, so these normal, specific radiological features should be taken into consideration during the neonatal period.

During the first hours of a neonate's life, transitory cardiomegaly may occur as a result of additional blood inflow from the placenta into the umbilical cord before its cutting, and of the presence of a bidirectional shunt through the arterial duct and oval foramen before its closure. Also, a prominent pulmonary vascularization may be observed as a result of residual lung fluid absorption through the lymphatic-venous system. A still open arterial canal may be seen on a chest x-ray as a convex prominence to the left of the spine, between T3 and T4 vertebras, this configuration being denominated *ductus bump*, that is considered as a typical radiological finding at the neonate first hours of life[1,2] (Figure 4).

The oval foramen and arterial canal closure, the decrease in pulmonary vascular resistance and absorption of the remaining lung fluid in the hours subsequent to the birth reduce the cardiac dimensions and the chest vascular prominence.

In neonates, the thymus is radiologically characterized by a widening of the upper mediastinum, above the cardiac image, on the frontal view, and an increase in the supracardiac, retrosternal density on the profile incidence (Figure 5). On the frontal view, the normal width of the thymic image must be higher than the double-width of the third thoracic vertebra, shorter dimensions representing a sign of thymic involution[7] (Figure 6). Under stress —

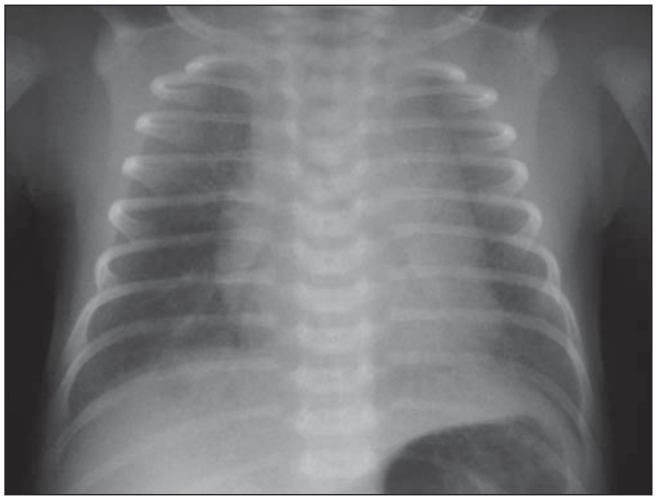


Figure 1. Normal chest x-ray of a two-hour-old newborn infant, in compliance with technical standards.

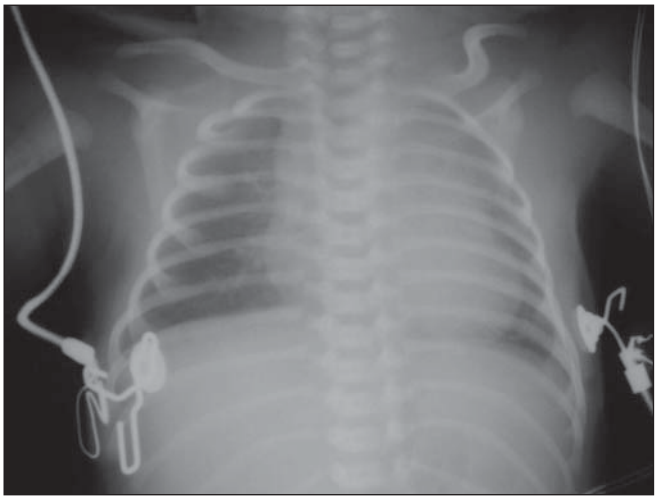


Figure 2. Oblique chest x-ray of a newborn infant demonstrating bilateral clavicles and costal arcs asymmetry.

fever, infections, congenital cardiopathies, pulmonary diseases, malnutrition —, there may be a rapid thymic involution as a result of the adrenal corticosteroid action, and yet its image may not be visualized on chest x-rays[8] (Figure 7). This accidental involution may revert once the stress situation is overcome, and the thymus returns to its normal dimensions. Also, the thymus may present peculiar features, including the "wave sign" corresponding to a gentle undulation on the thymus surface produced by costal arcs compression, more frequently to the left; the "notch sign", where the inferior border of the normal thymus blends with the border of the cardiac silhouette; and the "sail sign" resulting from a peculiar shape of the thymus appearing like a normal anterior mediastinal sail shaped structure, more frequently to the right[1,2] (Figures, 8, 9 and 10).

EXTRATHORACIC STRUCTURES

Soft tissues, the skeletal structure and the abdomen may provide relevant information for clinical management of neonates.

The thickness of the thoracic wall soft tissues reflects the nutritional condition, and may be decreased in light-weight newborn infants[9].

Secondary ossification nuclei of the proximal humeral extremity and coracoid apophysis may be visualized on chest x-rays, and a relation is established between the presence of these ossification nuclei and the term gestational age of the neonate, therefore representing a sign of fetal maturity[10] (Figure 11).

Typically, the presence of air may be observed in the stomach right at birth, small bowel with three hours of live, and in the rectum, six to eight hours after birth, so it is always important to correlate radiologi-

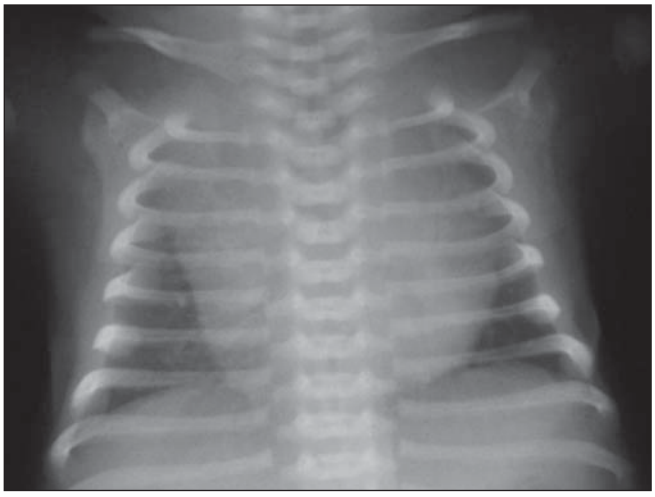


Figure 3. Two-hour-old newborn infant chest x-ray with x-ray tube misalignment. Anterior costal arcs present cephalic orientation, projecting themselves above their posterior segments.

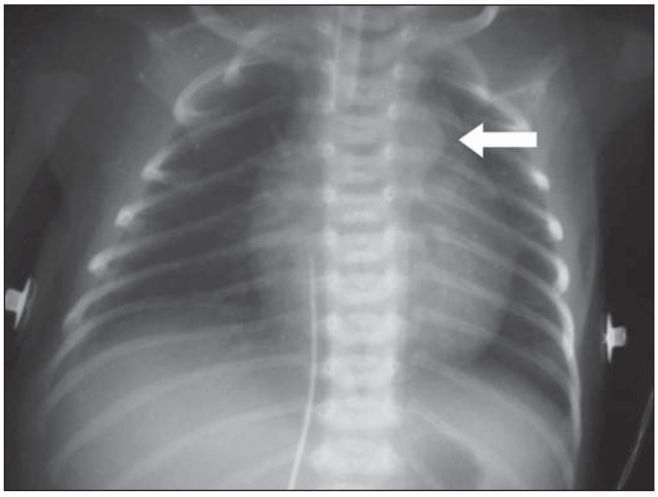
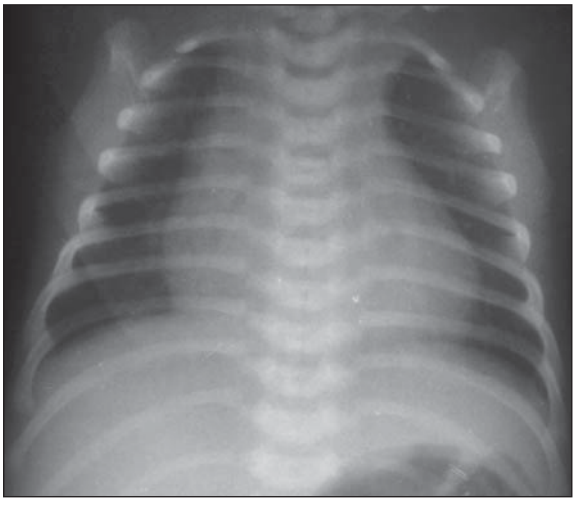


Figure 4. One-day-old newborn infant chest x-ray demonstrating the ductus bump (arrow).



A

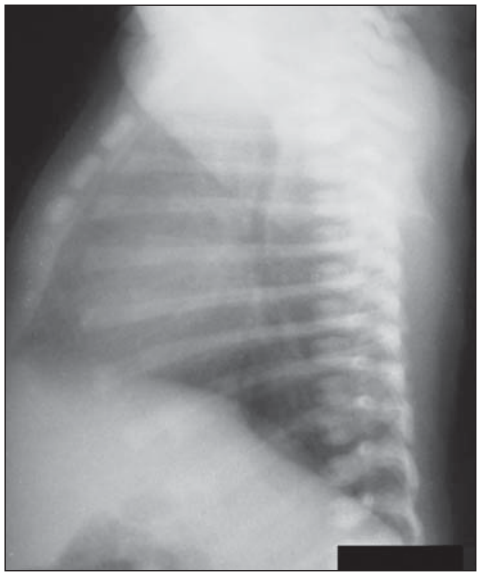


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Figure 5. Chest x-ray anteroposterior and lateral views, demonstrating normal cardiothymic image.

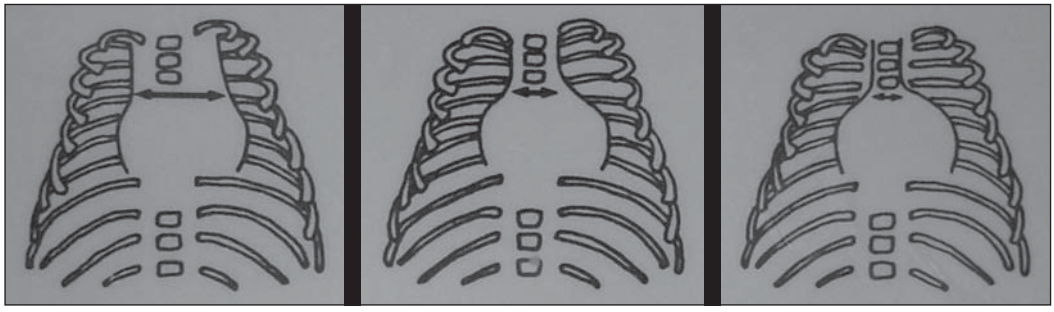
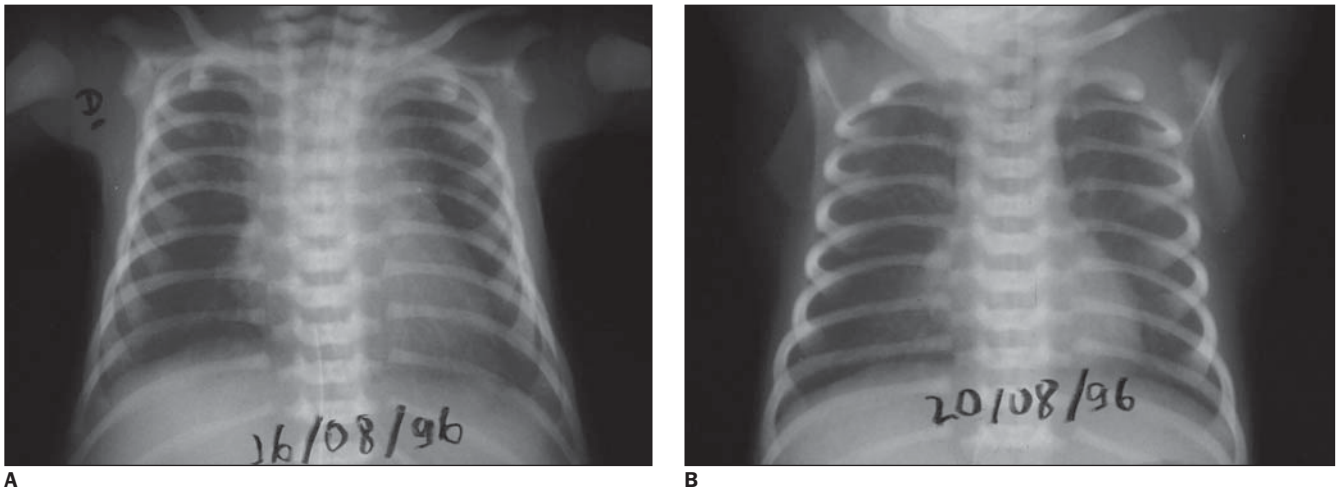


Figure 6. Scheme showing criteria for evaluation of thymic image dimensions.



A B

Figure 7. Chest x-ray of (**A**) three-hour-old, and (**B**) four-day-old newborn infant, showing thymus involution.

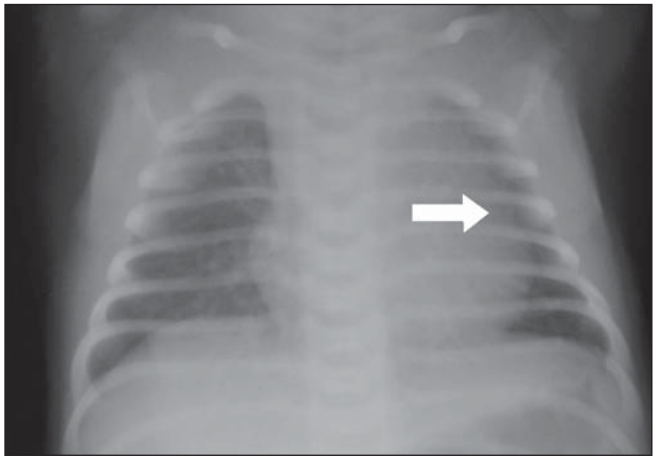


Figure 8. Nine-day-old newborn infant x-ray demonstrating "wave-sign" (arrow).

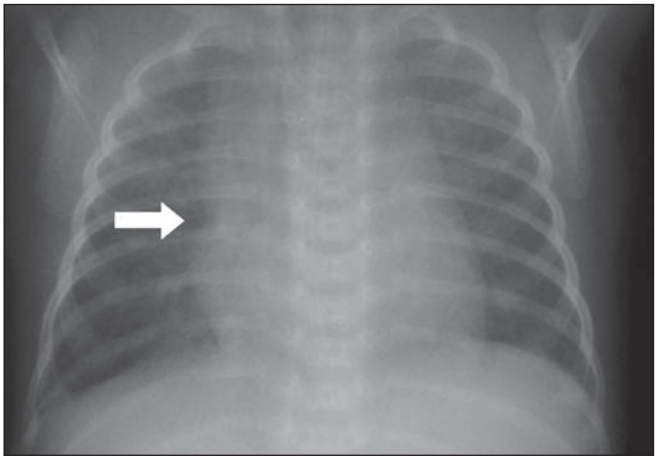


Figure 9. Twenty-two-day-old newborn infant x-ray demonstrating "notch-sign" (arrow).

cal findings with the neonate's number of hours of life[2].

CATHETERS, CANNULAS AND PROBES

In the analysis of chest and abdomen x-rays, it is very important to describe the localization of cannulas, probes and catheters, since the incorrect positioning of these tubes may cause iatrogenies[2,11].

The umbilical venous catheter follows its course through the umbilical vein, venous duct and inferior vena cava, presenting a straight course at the right side of the thoracic-lumbar spine. The correct site for its extremity is the inferior vena cava, nearby the right atrium entry at right of T8-T9[2,12] (Figure 12). The umbilical arterial catheter presents a small curvature in its entry into the right or left umbilical artery, passing through the internal and common iliac arteries up to the abdominal aorta where it is placed preferably above the

level of iliac arteries bifurcation at L3-L5 — low localization—, or in the thoracic aorta under the arterial canal between T7 and T9 — high localization[2,12] (Figures13 and 14). Umbilical catheters should not be situated in the origin of smaller caliber vascular trunks under the risk of precipitating spasms and thrombosis.

In patients under assisted respiration, the endotracheal intubation cannula should be placed in the medium third of the trachea, above the carina, and is visualized at T4 level and below the medial clavicle[2,4]. In patients with gastric probing, the probe should be visualized at the right of the tracheal cannula and its end should be located in the stomach (Figure 15).

IMAGE ARTIFACTS

Artifacts must be identified, since ignoring their peculiarities may induce the diagnosis of inexistent diseases by the interpreter-physician. One of the most frequent image artifacts are the skin folds projected over the thoracic cavity, and may simulate pneumothorax. The differential diagnosis is made by observing this artifact as a dense, linear image presenting an obliquity as opposed to the lung border, extending below the thoracic cavity[1,2,4] (Figure 16). Another eventual image artifact is the projection of the neonatal incubator access ports producing lower density round images which may be confused with cystic lesions[1,2,4] (Figure 17).

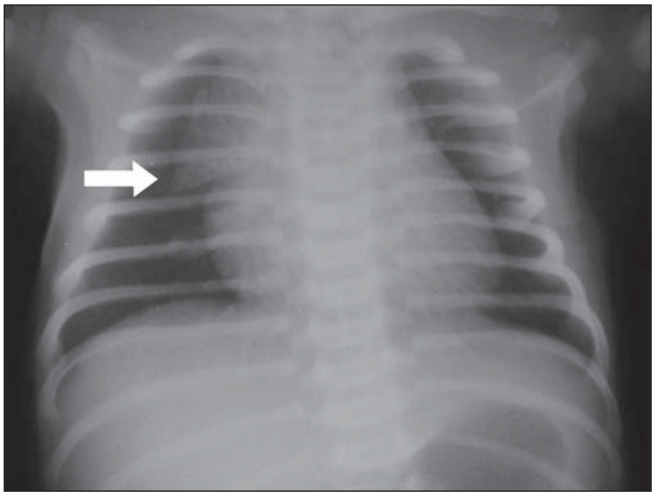


Figure 10. Three-hour-old newborn infant x-ray presenting the "sail sign" (arrow).

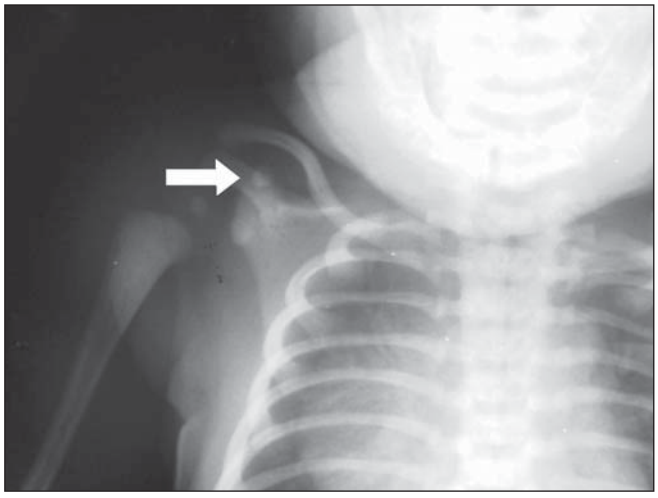


Figure 11. Twenty-four-hour-old new born infant chest x-ray focusing on the right shoulder, showing nuclei of secondary ossification on the proximal humerus end, and scapula coracoid process (arrow).

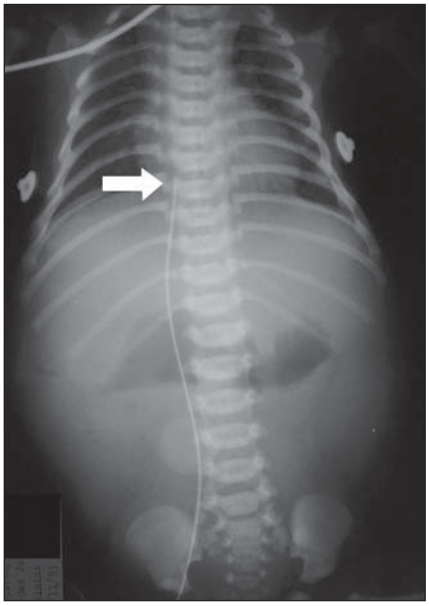


Figure 12. Twenty-four-hour old newborn infant chest and abdomen x-ray presenting venous umbilical catheter localized in the inferior vena cava (arrow).

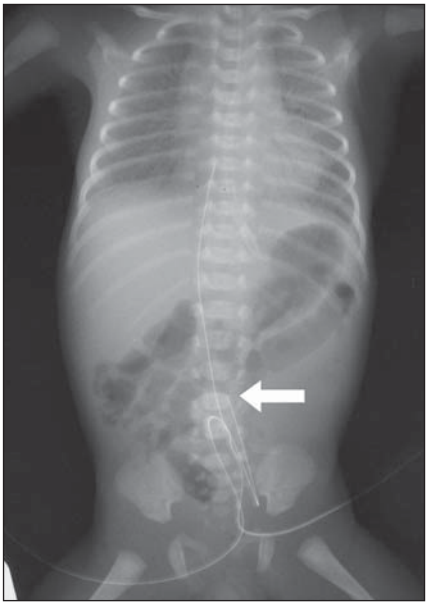


Figure 13. Newborn infant x-ray demonstrating low-localization of arterial umbilical catheter at the L4 level (arrow).

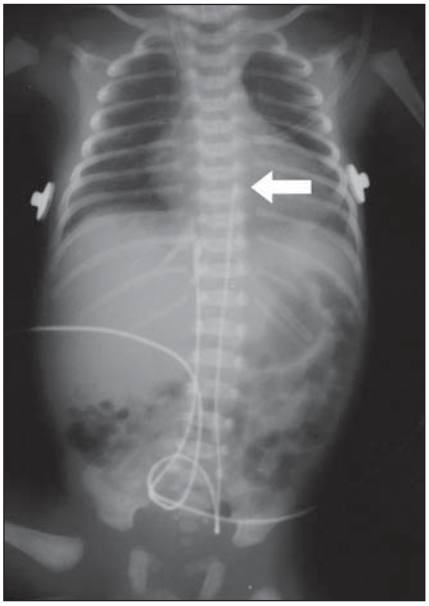


Figure 14. Newborn infant x-ray showing high-localization of arterial umbilical catheter (arrow).

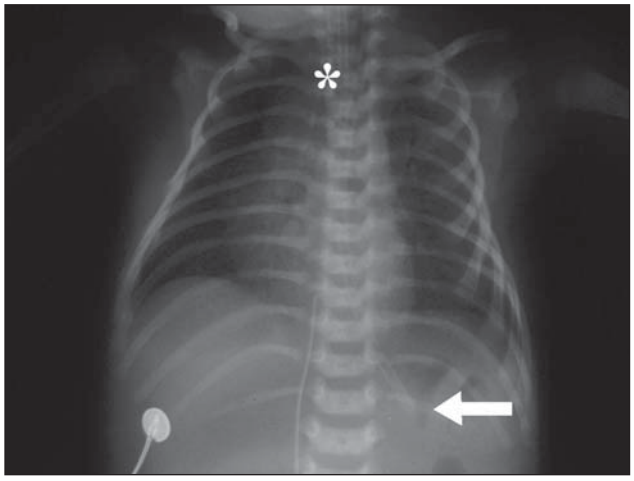


Figure 15. Three-day-old newborn infant x-ray showing endotracheal cannula placed above the carina (asterisk) and the nasogastric probe with its end localized in the stomach (arrow).

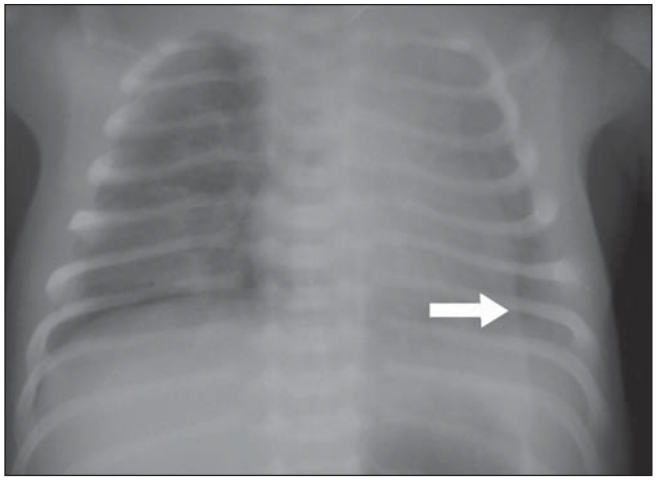


Figure 16. Newborn infant chest x-ray showing skin fold at left (arrow).

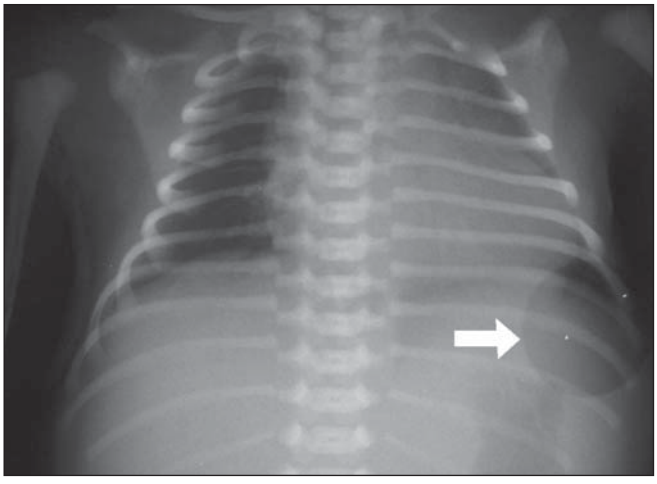


Figure 17. One-hour-old newborn infant x-ray demonstrating artifact related to projection of neonatal incubator access port (arrow).

CONCLUSION

The chest x-ray is a valuable support in the diagnosis and clinical follow-up of neonates, especially those requiring intensive care. The knowledge on particularities and normal radiological aspects of the neonate's chest avoids misdiagnosis, reduces iatrogenies and is of help in the diagnosis and clinical follow-up of these patients.

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