Title
Movement artifacts in pediatric cutaneous ultrasonography

Journal
Dermatology Online Journal, 25(1)

Authors
Rodríguez Bandera, Ana Isabel
Stewart, Nicholas
de la Cruz Troca, Juan José
et al.

Publication Date
2019

DOI
10.5070/D3251042609

Movement artifacts in pediatric cutaneous ultrasonography

Ana Isabel Rodríguez Bandera[1] MD PhD, Nicholas Stewart[2] FACD, Juan José de la Cruz Troca[3] PhD, Eva María Andrés Esteban[4] PhD, Marta Feito Rodríguez[1], Raúl de Lucas Laguna[1] MD

Affiliations: [1]Department of Dermatology, University Hospital La Paz, Madrid, Spain, [2]The Skin Hospital, Darlinghurst and Westmead, Sydney, Australia, [3]Department of Preventive Medicine and Public Health, Faculty of Medicine, Universidad Autónoma, Madrid, Spain, [4]Department of Preventive Medicine and Public Health, Faculty of Medicine, Universitat Jaume I, Castelló, Spain

Corresponding Author: Ana Isabel Rodríguez Bandera MD, PhD, University Hospital La Paz, Paseo de la Castellana 261, 28046, Madrid, Spain, Tel: 34-917277231, Email: anarb85@gmail.com

Abstract

Background: Cutaneous ultrasonography can be challenging in children. We aim to identify the most complicated cases and the best timing for assessment.

Methods: We retrospectively reviewed sonographic exams in pediatric patients from our cutaneous ultrasonography clinic over a two-year period. Movement artifacts were classified according to their consequences and their frequency was studied in relation to the age of the patient, location of the lesion, and underlying pathology.

Results: The overall frequency of exams affected by movement artifacts was 16.76% (91/543) and all belonged to children younger than 4 years of age. The frequency of impaired sonographies was particularly low in patients aged 0 to 4 months (12.77%; 6/47) and particularly high in children aged from 4 to 12 months (56.60%; 60/106). Regarding location, exams were more frequently disadvantaged when assessing the head and neck area (44.53%; 61/137). In relation to pathology, developmental anomalies showed a significantly higher frequency of exams damaged by movement artifacts (41.82%; 23/55).

Conclusions: Cutaneous ultrasonography without sedation can be particularly difficult in children aged between 4 and 12 months, especially when lesions are located on the head and neck and a Doppler exam is required. When assessing congenital lesions, the first four months of life are ideal for a first examination.

Keywords: ultrasound, children, movement artifacts, sedation, dermatology

Introduction

High-frequency ultrasonography (HFUS) is becoming an essential diagnostic tool in many dermatology departments. It has demonstrated its usefulness in pediatric dermatology, especially for the differentiation of various growths and tumors [1], follow-up of inflammatory diseases [2], the characterization of developmental anomalies [3], and the study of vascular anomalies [4].

When assessing children with HFUS, movement artifacts frequently compromise image quality and may interfere with interpretation. To ensure that the patient is cooperative throughout the examination, some authors have proposed distraction techniques similar to those used in other diagnostic or therapeutic procedures, such as feed and swaddle or the use of digital tablets [5]. However, others consider sedation necessary in selected patients, especially when a Doppler exam is required in patients under 4 years [6].

The objective of this study is to analyze the frequency of movement artifacts as well as determine the most complicated age, location, and pathology for which to perform HFUS.

Methods

We retrospectively reviewed sonographic exams and their reports performed on patients under 18 years

Table 1. *Types of movement artifacts and frequency.*

Type		Description	Absolute frequency	Relative frequency (%)
1	Difficult	Image quality is decreased but useful information is still shown in both bidimensional and Doppler mode.	13/91	14.29
2	No Doppler	Bidimensional images showed useful information but Doppler images were impossible to interpret or completely missing.	28/91	30.77
3	Impossible	Both bidimensional and Doppler images were impossible to interpret or completely missing.	50/91	54.95

of age in our cutaneous ultrasonography clinic between 2014-2016.

All examinations were performed and interpreted by a single dermatologist with specific training in cutaneous ultrasonography (advanced qualification (level 1 and 2) certified by the Spanish Society of Ultrasound and a record of more than 300 sonographic studies per year, as recommended by DERMUS, the international cutaneous ultrasonography working group [7]).

The environment was consistently arranged according to the age of the patient and parents were always present during the examination. When needed, feed and swaddle, explanations, and in-situ demonstrations of the technique and/or the use of digital tablets were employed. No sedation was used in any patient, and insufficient or impossible examinations related to movement artifact were aborted or postponed.

Movement artifacts were classified into three groups according to their consequences and their frequency was studied in relation to the age of the patient, location of the lesion, and type of pathology. Fisher's exact test was used to determine associations between categorical variables and P values <0.05 were considered statistically significant.

The Research Ethics Committee of the University Hospital La Paz (PI-2605) approved the study.

Results

Movement artifact frequency: We reviewed a total of 543 HFUS exams performed on patients under 18 years of age. Movement artifacts were found in 91/543 examinations (16.76%). However, in only 13/91 exams (14.29%) were the results regarded as completely unusable. Useful information was extracted from both bi-dimensional and Doppler mode in 28 of 91 affected examinations (30.77%) and from only the bi-dimensional mode in 50/91 examinations (54.95%), (**Table 1**).

Artifact movements and age: The average age of the overall patient sample was 5.4 years old (SD +/- 5.8). The average age of patients with examinations affected by movement artifacts was 0.59 years old (SD+/-0,84). Patients with difficult or unusable examinations were all younger than 4 years old.

Patients under 4 years old represented 53.59% of the sample (291/543) and 31.27% (91/291) of these patients made their examinations difficult or impossible.

To better identify the problematic ages for sonographic exploration, we differentiated four age groups within the under-4 cohort: 1) 0-to-4 months (limited physical development, fearless, natural sleep easily induced (up to 16-20 hours per day)): 47/291 (16.15%) patients; 2) 4-to-12 months (increased physical development, fearful, unable to understand and follow instructions): 106/291 (36.43%) patients;

Table 2. *Frequencies of the different types of movement artifacts according to group ages.*

Age groups	Movement artifacts			
	None	**Difficult**	**No Doppler**	**Impossible**
< 4 months	41	0	6	0
	87.2%	0.00%	12.8%	0.00%
4-12 months	55	21	31	8
	51.9%	11.3%	29.2%	7.5%
13-24 months	38	9	9	4
	63.3%	15.0%	15.0%	6.7%
25-48 months	66	7	4	1
	84.6%	9.0%	5.1%	1.3%
> 48 months	252	0	0	0
	100.00%	0.00%	0.00%	0.00%

P value <0.001.
(The difference in the frequency of movement artifacts between all the age groups (above) was statistically significant).

3) 13-to-24 months (higher physical development, able to start understanding and follow instructions): 60/291 (20.62%) patients and 4) 25-to-48 months (highest physical development and capacity to understand and follow instructions in cohort): 78/291 (26.80%) patients.

Statistically significant differences were observed when analyzing the frequency of movement artifacts according to these age groups (P value < 0.001), (**Table 2**, **Figure 1**). Babies younger than 4 months represented a particularly low frequency,

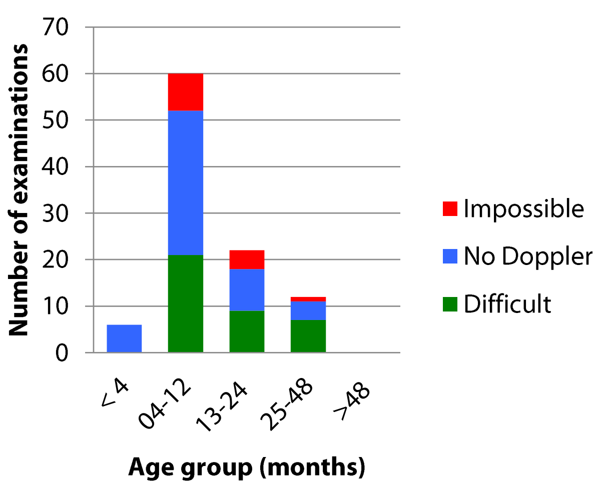

Figure 1. *Movement artifacts and consequences according to age groups.*

constituting only 6.59% (6/91) of all the affected exams. In addition, only 12.77% (6/47) of the exams in children under 4 months were affected, but none were completely unusable, with information from the two-dimensional mode consistently available.

Conversely, patients aged 4 to 12 months produced the most troublesome studies. 65.93% (60/91) of all exams with movement artifacts occurred in this age range, with 56.60% (60/106) of children having an unusable exam and 61.54% of all the unusable exams occurring in this group.

From one year of age, significant movement artifacts decreased progressively to completely disappear over the age of 4 years.

Artifact movement and lesion location: Statistically significant results were found when assessing movement artifact frequency according to location (P value <0.001). Most lesions in patients younger than 4 years old were located either on the head and neck (137/291; 47.8%) or the trunk (100/291; 34.36%) with fewer lesions located on the upper limbs (37/291; 12.71%) or the lower limbs (17/291; 5.84%).

Artifact movements were over-represented in lesions located on the head and neck with nearly half of the exams performed in these areas affected (61/137; 44.53%). Almost a third of trunk lesions exams were affected by movement artifacts (27/100;

Table 3. *Frequencies of the different types of movement artifacts according to the lesion location.*

Location	Movement artifacts			
	None	Difficult	No Doppler	Impossible
Head and neck	76	11	40	10
	55.47%	8.03%	29.20%	7.30%
Trunk	73	16	9	2
	73.00%	16.00%	9.00%	2.00%
Upper limbs	34	1	1	1
	91.89%	2.70%	2.70%	2.70%
Lower limbs	17	0	0	0
	100.00%	0,00%	0,00%	0,00%

P value <0.001.
(The difference in the frequency of movement artifacts between all the age groups (above) was statistically significant).

27%). The upper and lower limbs appeared easier to explore with 8.11 % (3/37) and no exams affected in these areas, respectively (**Table 3**, **Figure 2**).

A sub-analysis of areas on the head and neck was undertaken, with lesion location divided into three groups: 1) scalp (55/137; 40.15%); 2) periorificial areas/anterior neck fold (58/137; 42.34%); 3) other areas, including ears (24/137; 17.52%).

Periorificial areas/anterior neck fold and the scalp appeared to be the most difficult areas to examine, with 51,72% (30/58) and 45.54% (25/55) of these exams affected in some way by movement artifacts, respectively. Similarly, the majority of unusable exams were intended to explore either the periorificial location or the anterior neck fold (7/10; 70%). Other areas appeared easier to examine with just 25% of the exams affected by movement artifacts (**Table 4**, **Figure 3**). The obtained results also were statistically significant (P value <0.001).

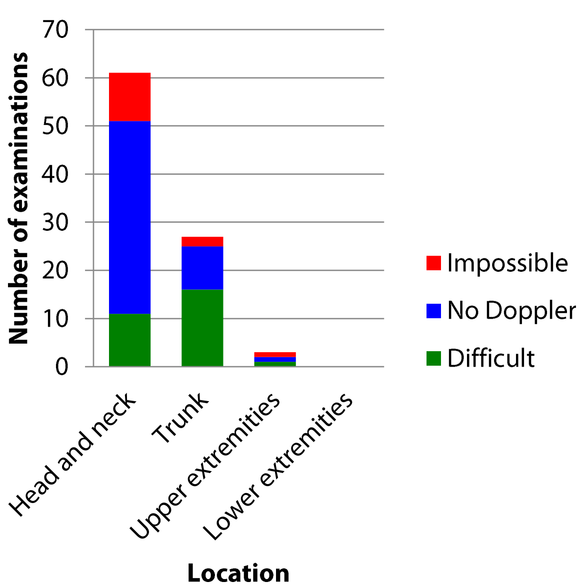

Figure 2. *Movement artifacts and consequences according to lesion location.*

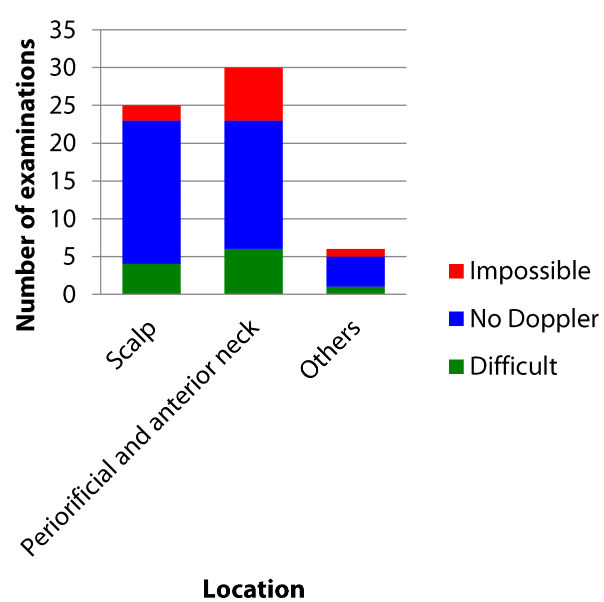

Figure 3. *Movement artifacts and consequences according to lesion location on the head and neck area.*

Table 4. *Frequencies of the different types of movement artifacts according to the lesion location on the head and neck..*

Location	Movement artifacts			
	None	Difficult	No Doppler	Impossible
Scalp	30	4	19	2
	54.55%	7.27%	34.55%	3.64%
Periorificial/anterior neck	28	6	17	7
	48.28%	10.34%	29.31%	12.07%
Other areas	18	1	4	1
	75.00%	4.17%	16.67%	4.17%

P value <0.001.
(The difference in the frequency of movement artifacts between all the age groups (above) was statistically significant).

Artifact movement and pathology type: Developmental anomalies (55/291; 18.90%) followed by vascular lesions (50/291; 17.18%) were the pathologies most frequently studied in children under 4 years of age. Tumors (non-vascular), and inflammatory diseases, respectively, represented 9.6% (28/291) and 7.90% (23/291) of the sample, respectively. The remainder (17/291; 5.84%) were classified as "miscellaneous," and included, amongst other entities, hamartomas and calcinosis cutis. No ungueal disorders were explored in this age group. Sonographic examination of developmental anomalies (23/55; 41.82%) and vascular lesions (50/162; 30.86%) were the most frequently disrupted by the lack of patient cooperation, but results were only significant for the latter (P value <0.049), (**Table 5**, **Figure 4**).

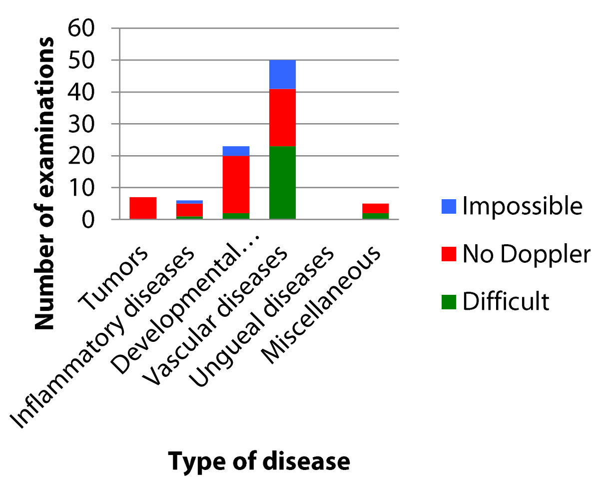

Figure 4. *Movement artifacts and consequences according to the underlying pathology.*

Discussion

Ultrasonography is a valuable non-invasive, harmless, and painless diagnostic tool, clearly suitable for children. However, assessing infants and preschool-aged children unable to understand and follow instructions can be challenging. Moreover, in cutaneous ultrasonography, patient immobility is paramount given the probe does not rest on the skin surface but must remain suspended within the layer of gel above the lesion. Studies using ultrasound for monitoring the evolution of infantile hemangiomas emphasize the difficulty of obtaining accurate images [8] and, in some cases, the technique has been declared impossible to perform owing to crying or constant movements [9, 10].

Thus, sedation has been suggested routinely when exploring infants and toddlers [6, 11]. Chloral hydrate, (50mg/kg) administered orally 30 minutes before the examination, has been proposed as an easy, effective, safe, and cost-effective sedation technique [6] that does not require the presence of an anesthesiologist [12]. It has been successfully used in magnetic resonance imaging (MRI), [12] and auditory brainstem response testing [13]. However, although rare, significant adverse events, such as apnea or bradycardia, and minor complications such as vomiting, hypoxemia, tachypnea, prolonged sedation, and restlessness have been reported [12, 13].

Given that safety is one of the main attractions of ultrasound and patient immobility is arguably easier with this modality (i.e. the patient must remain isolated and is surrounded by significant noise in MRI), the current trend is to encourage the use of alternative tactics to avoid sedation. Optimizing the physical environment may be helpful. For example, newborns and infants might be more amenable to examination in a dark and quiet area, whereas toddlers and preschoolers may feel more at ease in a bright and colorful location [14]. Psychological preparation can reduce anxiety in patients old enough to comprehend the explanation [14]. Demonstrating ultrasonography first on the patient's doll or on a parent can alleviate the fear of the unknown. Natural sleep can be easily induced in newborns and infants by feeding them 20 minutes before the examination [15]. Feeding during the examination or administering an oral sucrose solution can also be calming [5, 14]. A variety of innocuous techniques have been explored to relieve older children of pain, fear, and anxiety related to unpleasant procedures. These include active approaches, such as interactive toys (electronic and video games), virtual reality, controlled breathing, and guided imagery, and relaxation and passive methods, such as music or television [16]. Activities not requiring the patient to move are preferred in imaging tests and the use of cartoon books, digital tablets, or video goggles are used most commonly [5, 14].

Sometimes, regardless of the efforts to reduce patient motion, movement can significantly obstruct an examination. Therefore, knowledge of risk factors can enable the clinician to select the appropriate candidates and the appropriate timing to perform the examination, minimize unsuccessful exams, and allow planning of sedation only in those candidates in which it is most likely to be required. As the literature currently stands, very little information is available on this subject. Wortsman et al. recommend the use of chloral hydrate when using ultrasonography in patients younger than 4 years, particularly when a Doppler exam is desired[6]. Barkovich et al. point out that the age between 2 and 6 years is the most challenging [15].

According to our study, movement artifacts represented an issue only in patients younger than 4 years, supporting the recommendation to consider sedation in this age group [6]. However, less than a third of children younger than 4 years were difficult to assess owing to a lack of cooperation and in only very few cases was the exam aborted before obtaining any useful information. With this data, the suggestion to use sedation on a routine basis seems overly aggressive.

Our data suggests patients between 4 and 12 months can be particularly challenging, with very few problems found when assessing newborns and infants younger than 4 months. These results differ from Barkovich's experience, who identified children age from 2 to 6 years old as the most challenging age group, albeit during examination with MRI [15].

According to our study, the use of cutaneous ultrasound for lesions on the head and neck had the highest levels of movement artifact, with periorificial areas and the anterior neck fold the most problematic. The extremities appeared particularly accessible. Unfortunately, we have not found similar information in the literature with which to compare our results.

Regarding the underlying pathology, vascular lesions and developmental anomalies appeared to be the most challenging. However, results were only significant for the latter. We postulate that this type of pathology may require a more rigorous and time-consuming examination and is therefore more sensitive to movement.

Conclusion

In summary, our data suggests that ultrasonography is most likely to be impaired by movement artifact when children are aged between 4 and 12 months, when lesions are located on the periorificial areas or the anterior neck fold or scalp, and when a Doppler exam or more rigorous examination is required. When assessing congenital lesions, the first 4 months of life appear to be ideal for a first examination.

Using our findings it is hoped that the clinician will recognize potentially complicated cases and choose the appropriate timing for ultrasound, avoid or minimize the use of sedation, and enable a reduction in unsuccessful and unusable examinations.

References

1. Knopfel N, Gomez-Zubiaur A, Noguera-Morel L, Torrelo A, Hernandez-Martin A. Ultrasound findings in idiopathic facial aseptic granuloma: Case series and literature review. *Pediatric Dermatol*. 2018; 35(3):397-400. [PMID: 29120075].
2. Rodriguez-Bandera AI, Feito-Rodriguez M, Maseda-Pedrero R, de Lucas-Laguna R. Idiopathic Facial Aseptic Granuloma: Clinical and Ultrasound Findings in 3 Cases. *Actas Dermosifiliogr*. 2018;109(7):e1-e5. [PMID: 29217229].
3. Walsh R, North J, Cordoro KM, Rodriguez Bandera AI, Kristal L, Frieden IJ. Midline anterior neck inclusion cyst: A novel superficial congenital developmental anomaly of the neck. *Pediatric Dermatol*. 2018;35(1):55-8. [PMID: 29266365].
4. Kutz AM, Aranibar L, Lobos N, Wortsman X. Color Doppler Ultrasound Follow-Up of Infantile Hemangiomas and Peripheral Vascularity in Patients Treated with Propranolol. *Pediatr Dermatol*. 2015;32(4):468-75. [PMID: 25940359].
5. Rodríguez-Bandera AI, De-Lucas R. Usefulness of ultrasound in paediatric dermatology. *Piel*. 2016;31(4):233-5.
6. Wortsman X. Common applications of dermatologic sonography. *J Ultrasound Med*. 2012;31(1):97-111. [PMID: 22215775].
7. Wortsman X, Alfageme F, Roustan G, Arias-Santiago S, Martorell A, Catalano O, Scotto di Santolo M, Zarchi K, Bouer M, Gonzalez C, Bard R, Mandava A, Gaitini D. Guidelines for Performing Dermatologic Ultrasound Examinations by the DERMUS Group. *J Ultrasound Med*. 2016;35(3):577-80. [PMID: 26887446].
8. Talaat AA, Elbasiouny MS, Elgendy DS, Elwakil TF. Propranolol treatment of infantile hemangioma: clinical and radiologic evaluations. *J Pediatr Surg*. 2012;47(4):707-14. [PMID: 22498385].
9. Sans V, de la Roque ED, Berge J, Grenier N, Boralevi F, Mazereeuw-Hautier J, Lipsker D, Dupuis E, Ezzedine K, Vergnes P, Taieb A, Leaute-Labreze C. Propranolol for severe infantile hemangiomas: follow-up report. *Pediatrics*. 2009;124(3):e423-31. [PMID: 19706583].
10. Schiestl C, Neuhaus K, Zoller S, Subotic U, Forster-Kuebler I, Michels R, Balmer C, Weibel L. Efficacy and safety of propranolol as first-line treatment for infantile hemangiomas. *Eur J Pediatr*. 2011;170(4):493-501. [PMID: 20936416].
11. He L, Huang G. Spectral Doppler ultrasound for predicting long-term response to topical timolol in children with infantile hemangioma. *J Clin Ultrasound*. 2017;45(8):480-7. [PMID: 28369943].
12. Delgado J, Toro R, Rascovsky S, Arango A, Angel GJ, Calvo V, Delgado JA. Chloral hydrate in pediatric magnetic resonance imaging: evaluation of a 10-year sedation experience administered by radiologists. *Pediatr Radiol*. 2015;45(1):108-14. [PMID: 25142238].
13. Valenzuela DG, Kumar DS, Atkins CL, Beers A, Kozak FK, Chadha NK. Chloral hydrate sedation for auditory brainstem response (ABR) testing in children: Safety and effectiveness. *Int J Pediatr Otorhinolaryngol*. 2016;83:175-8. [PMID: 26968073].
14. Jaimes C, Gee MS. Strategies to minimize sedation in pediatric body magnetic resonance imaging. *Pediatric Radiol*. 2016;46(6):916-27. [PMID: 27229508].
15. Barkovich MJ, Li Y, Desikan RS, Barkovich AJ, Xu D. Challenges in pediatric neuroimaging. *Neuroimage*. 2019;185:.793-801. [PMID: 29684645].
16. Koller D, Goldman RD. Distraction techniques for children undergoing procedures: a critical review of pediatric research. *J Pediatr Nurs*. 2012;27(6):652-81. [PMID: 21925588].