

# Aspiration Pneumonia in Children with Cerebral Palsy after Videofluoroscopic Swallowing Study

Hellen Nataly Correia Lagos-Guimarães<sup>1</sup> Hélio Afonso Ghizoni Teive<sup>1</sup> Adriane Celli<sup>2</sup>  
 Rosane Sampaio Santos<sup>3</sup> Edna Marcia da Silva Abdulmassih<sup>1</sup> Gisela Carmona Hirata<sup>3</sup>  
 Liliane Friedrich Gallinea<sup>2</sup>

<sup>1</sup>Department of Internal Medicine, Universidade Federal do Paraná, Curitiba, Brazil

<sup>2</sup>Department of Child and Adolescent, Universidade Federal do Paraná, Curitiba, Paraná, Brazil

<sup>3</sup>Department of Communication Disorders, Universidade Tuiuti do Paraná, Curitiba, Paraná, Brazil

Address for correspondence Hellen Nataly Correia Lagos-Guimarães, MSc, Department of Internal Medicine, Universidade Federal do Paraná, Rua Antonio Nunes 1100, Cond Jatrim América, Mafra, SC 89300000, Brazil (e-mail: hellennataly@gmail.com).

Int Arch Otorhinolaryngol 2016;20:132–137.

## Abstract

**Introduction** Dysphagia is a common symptom in children with cerebral palsy, either in oral or pharyngeal phases. Children who face such difficulties tend to show health problems such as food aspiration, malnutrition and respiratory infections. Videofluoroscopic swallowing study is the most recommended for these cases, as it reveals the real situation during swallowing.

**Objective** The study aimed to verify the occurrence of aspiration pneumonia in children with cerebral palsy after videofluoroscopy.

**Methods** The population for this prospective cross-sectional study involved 103 children with cerebral palsy, referred for videofluoroscopic who had returned for medical examination after a week to search for signs and symptoms of pneumonia.

**Results** The study involved 46 girls (44.66%) and 57 boys (55.34%), aged between 0 and 14 years of age. Of the total, 84 (81.5%) had dysphagia, of which 24 (23.3%) were severe, 8 (7.7%) were moderate and 52 (50.4%) were mild dysphagia. None of the children presented aspiration pneumonia or infectious complications during the course of videofluoroscopy or after the procedure.

**Conclusion** In the population studied, the authors found no cases of aspiration pneumonia, even with tracheal aspiration present in 32 (31.07%) cases.

## Keywords

- ▶ deglutition
- ▶ deglutition disorders
- ▶ fluoroscopy
- ▶ cerebral palsy
- ▶ aspiration pneumonia

## Introduction

Considered one of the most common diseases during early childhood,<sup>1</sup> cerebral palsy is characterized by non-progressive neurological impairment, with postural and development disorders.<sup>2–4</sup> It is caused by injury to the immature brain, interfering with the maturation of the central nervous system in infancy, occurring in the pre-, peri-, or postnatal

periods. The diagnosis generally occurs prior to two years of age.<sup>2</sup>

Dysphagia is a frequent symptom of cerebral palsy.<sup>6</sup> The patient may present abnormal oral phase, pharyngeal phase, or both, known as oropharyngeal dysphagia.<sup>1</sup> Around 43% of children with cerebral palsy have dysphagia.<sup>1</sup> The most common difficulties are poor cervical control, inefficient lip closure, preparation and bolus propulsion deficiency,

received  
February 11, 2015  
accepted  
July 14, 2015  
published online  
October 20, 2015

DOI <http://dx.doi.org/10.1055/s-0035-1566093>.  
ISSN 1809-9777.

Copyright © 2016 by Thieme Publicações Ltda, Rio de Janeiro, Brazil

License terms



swallowing reflex delay, laryngeal penetration, and/or tracheal aspiration.<sup>5</sup>

The videofluoroscopic swallowing study is useful in the diagnosis of dysphagia. It involves a magnetic media recorder for dynamic images generated by exposing patients to X-ray. It uses dynamic real-time recording and stores information in magnetic media, allowing a morphological and physiological evaluation of the swallowing process.<sup>7</sup> Videofluoroscopy is the most recommended instrumental assessment for children, as it reveals the real situation during swallowing,<sup>8</sup> allowing the assessment of oral and pharyngeal phases.<sup>7,9</sup> Thus, the dysphagia diagnosis is performed more reliably so as to adequately guiding therapy.<sup>7</sup>

As for problems in performing videofluoroscopy in dysphagic children, there has been no research directed toward this issue. Some authors suggest that one of the complications in the videofluoroscopic swallowing study is that patients with the disorder may be exposed to the risk of contrast aspiration.<sup>10</sup> Other studies indicate that children with severe dysphagia are at high-risk of complications during the procedure, but do not provide scientific evidence.<sup>11</sup> The objective of this study is to assess the presence of aspiration pneumonia in children with cerebral palsy after the videofluoroscopic swallowing study.

## Methods

The Ethics in Research Committee of the Universidade Tuiuti do Paraná (CPE/UTP) approved this prospective cross-sectional study and the approval is registered under 000025/2009.

The study population consisted of 103 children with cerebral palsy, consisting of 46 girls (44.66%) and 57 boys (55.34%), aged between 0 and 14 years, with an average of 4.26 years of age and a standard deviation of 4.18. They were referred to videofluoroscopic swallowing study by various specialties of the pediatrics department in the period between September 2009 and December 2012.

The study criteria included children of both genders, aged between 0 months and 14 years, diagnosed with cerebral palsy as the underlying disease, with suspicion of dysphagia, clinically stable, awake and alert, having performed videofluoroscopic swallowing study and returning for follow-up within one week after the swallowing study. The authors excluded children with a current diagnosis of aspiration pneumonia and those whose parents and/or legal guardian refused to sign the Informed Consent.

The authors collected underlying disease diagnosis and basic personal data from each child's records and interviewed their respective parents and/or legal guardians. The authors discarded prior pneumonia through a chest radiography performed at the beginning of the videofluoroscopic swallowing study.

The videofluoroscopic swallowing study was performed with a Siemens Axiom R100 device, M44–2 Siemens monitor, which was also used to perform the chest radiography.

During the assessment, the child remained seated in an adapted chair adjusted to 90° or, when necessary, in the mother or guardian's lap, with a lateral radiographic view.

Feeding utensils available were a cup, spoon, plastic syringe, straw, and, when necessary, the child's own bottle.

The consistencies presented were pudding, honey, nectar, and liquid, using the American Dietetic Association nomenclature.<sup>11</sup> To obtain these consistencies, the researchers used water, Barium Sulfate 100% from Bariogel (as radiological contrast, which contains 1 g barium sulfate and 1 mL gsp vehicle for pediatric and adult use) and modified cornstarch food thickener THICK UP (composed of modified cornstarch - E1442, maltodextrin, tara gum, xanthan gum and guar gum).

Recordings of the videofluoroscopic study were made with a HP Pavilion tx2075BR Notebook and Sapphire image collector, model Wonder TVUSB.

Personal information and test results were collected according to a previously established protocol.

Classification of dysphagia was based on the Videofluoroscopic Dysphagia Severity Classification.<sup>12</sup>

One week after the test date, the children returned for speech pathology and medical follow-up.

Criteria for the definition of aspiration pneumonia was the presence of fever ( $T \geq 37.8^\circ\text{C}$ ), cough or purulent sputum associated with pulmonary auscultation, and radiological evidence of pulmonary condensation.<sup>13</sup> Suspected cases underwent new chest radiography.

For statistical analysis, the researchers used the average for descriptive statistics and chi-square test for variables association. Statistical significance was considered as  $p < 0.05$ . The software used was Statistica 7 (Statsoft, France).

## Results

► **Table 1** shows the sample distribution of dysphagia severity according to the classification<sup>12</sup>, where mild dysphagia is the most common, followed by severe dysphagia.

► **Table 2** shows the relationship between dysphagia severity and nutrition support, inferring a high prevalence of children with severe dysphagia with exclusive oral nutrition support. In this case, the chi-square test was inapplicable.

► **Table 3** shows the relationship between dysphagia and the presence of previous pneumonia can be seen in. These data include all children who had pneumonia at least once. The chi-square test analysis at a significance level of 0.05 revealed no significant relationship ( $p = 0.1312$ ).

**Table 1** Sample distribution according to dysphagia severity

Severity	Frequency	%
Normal	19	18.45
Mild	52	50.49
Moderate	8	7.76
Severe	24	23.30
TOTAL	103	100.00

Source: Lagos-Guimarães HNC.

**Table 2** Relationship between dysphagia severity and nutrition support

Dysphagia severity	Nutrition support			Total
	Gastrostomy	Nasogastric tube	Oral Intake	
Normal	2	2	15	19
Mild	4	2	46	52
Moderate	–	–	8	8
Severe	4	3	17	24
TOTAL	10	7	86	103

Source: Lagos-Guimarães HNC.

**Table 3** Relationship between dysphagia and previous pneumonia

Dysphagia severity	Previous pneumonia		Total
	No	Yes	
Normal	12	7	19
Mild	36	16	52
Moderate	4	4	8
Severe	10	14	24
TOTAL	62	41	103

Source: Lagos-Guimarães HNC.

The Chi-square test at a significance level of 0.05 analysis revealed no significant relationship ( $p = 0.1312$ ).

Of the 32 (31.07%) children who had tracheal aspiration, 10 (31.24%) aspirated liquid consistency, the highest occurrence during videofluoroscopic study, as seen in **Table 4**.

**Table 5** shows the relationship between the presence or absence of tracheal aspiration and age. Considering two age categories (up to 5 months and 6 months or more), the chi-square test reveals a significant relationship ( $p = 0.0012$ ) between presence or absence of tracheal aspiration and age in this sample.

**Table 6** shows the presence and absence of tracheal aspiration during the videofluoroscopic swallowing study, relating these data with the occurrence of aspiration pneumonia

after the test had not found any case of pneumonia. Only 1 out of 32 children who had tracheal aspiration required a chest X-ray, as the child had a phlegm cough, respiratory distress, and pneumonia, albeit unconfirmed.

**Table 7** shows the relationship between dysphagia severity and silent aspiration, with higher occurrence in severe dysphagia cases.

Considering only moderate and severe dysphagia cases, the chi-square test resulted in  $p = 0.0114$  at a significance level of 0.05 (5%). This reveals a significant higher proportion of silent aspiration in severe dysphagia cases.

## Discussion

Among children with cerebral palsy in the present study, 84 (81.5%) had dysphagia, being 24 (23.3%) severe dysphagia, 8 (7.7%) moderate dysphagia, and 52 (50.4%) mild dysphagia.

In a research conducted with 50 children with cerebral palsy, 100% of the sample had some type of dysphagia.<sup>14</sup>

Another epidemiological study conducted in Northern Ireland found that, out of 1,357 children assessed, the prevalence of dysphagia was 43% in children with cerebral palsy, regardless of its classification.<sup>1</sup> These studies show that the presence of dysphagia in children with cerebral palsy is common, with occurrence ranging from 43 to 100%, independent of motor or oral classification.

This study resulted in a had a higher incidence of mild dysphagia, showing a greater impairment of lip closure, preparation, and bolus propulsion to pharynx. This indicates a predominantly oral phase impairment, confirming data

**Table 4** Sample distribution according to aspirated consistency

Consistency	Frequency	%
Liquid	10	31.24
Honey/Nectar/Liquid	3	9.38
Nectar/Liquid	3	9.38
Pudding	4	12.50
Pudding/Honey	1	3.13
Pudding/Honey/Liquid	3	9.38
Pudding/Honey/Nectar/Liquid	3	9.38
Pudding/Nectar/Liquid	5	15.61
TOTAL	32	100.00

Source: Lagos-Guimarães HNC.

**Table 5** Relationship between tracheal aspiration and age

Tracheal aspiration	Age (months)		
	Less than 2	2 to 5	6 or more
Absent	35 (33.98%)	21 (20.39%)	15 (14.56%)
Present	7 (6.80%)	8 (7.77%)	17 (16.50%)
Total	42	29	32

Source: Lagos-Guimarães HNC.

Obs.: Considering two age categories (up to 5 months and 6 months or more), chi-square test reveals a significant relationship ( $p = 0.0012$ ) between presence or absence of tracheal aspiration and age in this sample.

**Table 6** Distribution of sample according to tracheal aspiration during videofluoroscopy

Tracheal aspiration	Frequency	%
Absent	71	68.93
Present	32	31.07
TOTAL	103	100.00

Source: Lagos-Guimarães HNC.

**Table 7** Relationship between dysphagia severity and silent aspiration

Dysphagia severity	No aspiration	Silent aspiration		Total
		No	Yes	
Moderate	–	6	2	8
Severe	–	6	18	24
TOTAL	71	12	20	103

Source: Lagos-Guimarães HNC.

Obs.: Considering only moderate and severe dysphagia cases, chi-square test, at a significance level of 0.05 (5%), resulted in  $p = 0,0114$ , revealing a significant higher proportion of silent aspiration in severe dysphagia cases.

from other studies<sup>15,16</sup> in which most of the children had oral phase compromise, with absence of oral movements in food preparation and ejection in 100 and 90% of cases, respectively.

The second most frequent was severe oropharyngeal dysphagia, found in 24 (23.30%) children in this study. This implicates both the oral and the pharyngeal phase, with tracheal aspiration and/or absence of the swallowing reflex. These patients need to be evaluated by qualified professionals during videofluoroscopic swallowing study, because studies show that children with severe dysphagia are at high risk of complications during the examination<sup>17</sup> and tracheal aspiration is a risk factor for aspiration pneumonia.<sup>18</sup>

In addition to children with severe dysphagia, the eight children who had moderate dysphagia (7.77%) were also classified with oropharyngeal dysphagia, since this category presents oral phase impairment, pharyngeal residue, laryngeal penetration or aspiration for only one food consistency.<sup>12</sup>

Another research found that 70% of the children studied had their pharyngeal phase compromised, with choking as the most prevalent symptom, which is in accordance with this research.<sup>16</sup> Other authors found that, of the 27 children with

cerebral palsy who had a history of recurrent pneumonia, 16 had pharyngeal dysphagia.<sup>19</sup>

In this study, out of the 24 children with severe dysphagia, 14 had recurrent pneumonia; however, out of the 19 children without dysphagia, seven also had a history of pneumonia. This indicates that other causes of recurrent pneumonia may be relevant, such as asthma.

Another important finding was that, out of the 24 children who had severe dysphagia with aspiration, only seven had been receiving enteral nutrition and 17 had received exclusively oral nutrition, despite their history of recurrent pneumonia. This demonstrates a delay in the indication of enteral feeding tube for patients with contraindication of oral intake, due to the presence of aspiration and associated pneumonia.

Other data found showed that, out of 24 patients with severe dysphagia and 8 with moderate dysphagia, 10 and 4 children, respectively, had no history of previous pneumonia. Thus, pneumonia does not only depend on tracheal aspiration, but also on the susceptibility of the individual, such as immunity.

The development of pneumonia requires three prerequisites;<sup>18</sup> the aspirated material needs to contain pathogenic germs, it necessarily must be aspirated and lungs need to be unable to resist pathogens. These data will be critical in multidisciplinary clinical evaluations for the indication of feeding tubes, since children with massive tracheal aspiration do not necessarily evolve to aspiration pneumonia.<sup>20</sup>

Regarding aspirated consistencies, this study found a higher occurrence with liquid. Other studies also found this result.<sup>8,14,15,21</sup>

In a study with 150 children with dysphagia, the authors observed a greater number of pneumonia cases in children who aspirated liquid consistency, whereas, those who aspirated thickened liquid and puree developed less cases of pneumonia.<sup>22</sup> This enables an alternative for food consistency management, with the use of thickeners before an indication of gastrostomy.

These findings show that caution is required during a clinical swallowing evaluation. This is especially true for the liquid consistency, since it is most likely to be aspirated by the patient due to poor oral control, leading to premature spillage into the pharynx and possibly tracheal aspiration. This was the most frequent finding in a study with 68 children with chronic non-progressive encephalopathy, of which 36 (53.0%) had premature spillage of bolus into pharynx.<sup>23</sup>

The research further shows that, the longer it takes for the swallowing reflex to trigger, the greater the chance of aspirating food, as the airway remains open and unprotected until the swallowing reflex is triggered.<sup>23</sup>

Older children must be managed carefully, as a significant relationship between tracheal aspiration and age was found, with  $p = 0.0012$ , with a higher incidence in children older than 6 months. This may be justifiable because systematic aspiration of saliva and/or food promotes desensitization of the cough reflex by the constant presence of food in the larynx and trachea, causing a decrease in airway protection, becoming a silent aspiration.<sup>24</sup>

The silent aspiration is characterized by aspiration of food with the absence of clinical signs such as coughing, gagging, or similar, being very common in children with neurological impairment.

In this study, out of 24 children who aspirated, 20 (19.42%) had silent aspiration, 18 of which had severe dysphagia and two had moderate dysphagia, thus presenting a significantly higher proportion of cases with silent aspiration in children with severe dysphagia.

It is important to note that tracheal aspiration is often silent, and the physician cannot detect it in a clinical examination. In some cases, the specialist can infer aspiration; however, for an objective confirmation, they should perform a videofluoroscopy.<sup>15</sup> This is the best choice for children, as it is not invasive, it can assess the oral and pharyngeal phases, and it even detects the presence of silent tracheal aspiration.<sup>6,8</sup>

However, there is a common sense that tracheal aspiration of barium during videofluoroscopic swallowing study may be a booster for the occurrence of aspiration pneumonia, putting in its use into question, since pneumonia is a

major cause of hospitalization for children aged 0 to 3 years old, ~41–42%.<sup>22</sup>

The literature does not provide data on the risks of carrying out the test, especially the risk of aspiration its application. In a study with 68 children with chronic non-progressive encephalopathy, none had posterior complications or infectious complications. However, the research used the fiberoptic endoscopic evaluation of swallowing and the contrast was blue or green aniline, unlike the videofluoroscopy, which uses Barium Sulfate, considered more harmful to health.<sup>23</sup>

When relating tracheal aspiration during videofluoroscopic swallowing study and occurrence of aspiration pneumonia after its realization, results showed neither infectious complications nor cases of pneumonia. Although 32 (31.07%) children aspirated during the procedure, this finding supports the results found in a survey, where 50% of the 16 children assessed with different underlying diseases had tracheal aspiration and there was not a single case of aspiration pneumonia.<sup>8</sup> However, the study used a small sample and did not determine a well-defined disease; therefore, this current research complements and reinforces earlier research, as it relies on a larger sample of patients and a well-defined pathology.<sup>8</sup>

Only one of the children in this study needed a chest radiography during follow-up, because he/she had signs and symptoms of pneumonia, cough with phlegm, and respiratory distress, although the additional medical and X-ray evaluation did not confirm this. These results contradict publications that mention the risk of aspiration of contrast as one of the complications of the videofluoroscopic swallowing study.<sup>10</sup>

Thus, it is important to complement clinical swallowing evaluation whenever required and possible by the instrumental assessment, unhindered by concerns about the child's clinical worsening. After all, it is necessary to make a reliable diagnosis and provide guidance that supports the safe therapeutic management of patients.

The radiation levels used for the examination are considered low and acceptable, considering the amount of information gathered,<sup>25</sup> and its use is justifiable given the better cost-benefit ratio of choosing videofluoroscopy.<sup>26</sup>

## Conclusion

In this population, there were no cases of aspiration pneumonia, even with tracheal aspiration present in 32 (31.07%) cases.

## References

- 1 Erasmus CE, van Hulst K, Rotteveel JJ, Willemsen MAA, Jongerius PH. Clinical practice: swallowing problems in cerebral palsy. *Eur J Pediatr* 2012;171(3):409–414
- 2 Ashwal S, Russman BS, Blasco PA, et al. Practice Parameter: Diagnostic assessment of the child with cerebral palsy. *Neurology* 2004;62(6):851–863
- 3 Dias ACB, Freitas JC, Formiga CKMR, Viana FP. Desempenho funcional de crianças com paralisia cerebral participantes de tratamento multidisciplinar. *Fisioter Pesqui* 2010;17:225–229

- 4 Hirata GC, Santos RS. Rehabilitation of oropharyngeal dysphagia in children with cerebral palsy: A systematic review of the speech therapy approach. *Int Arch Otorhinolaryngol* 2012;16(3):396–399
- 5 Furkim AM, Duarte ST, Sacco AFB, Sória FSO. Uso da ausculta cervical na inferência de aspiração traqueal em crianças com paralisia cerebral. *CEFAC* 2009;11:624–629
- 6 Arvedson J, Rogers B, Buck G, Smart P, Msall M. Silent aspiration prominent in children with dysphagia. *Int J Pediatr Otorhinolaryngol* 1994;28(2–3):173–181
- 7 Costa MMB. Videofluoroscopia: método radiológico indispensável para a prática médica. *Radiol Bras* 2010;43:VII–VIII
- 8 Lagos HNC, Santos RS, Celli A, Abdulmassih SEM, Medeiros CAA. Ocorrência de pneumonia aspirativa em crianças disfágicas pós videofluoroscopia. *Int Arch Otorhinolaryngol* 2011;15:437–443
- 9 Bonilha HS, Humphries K, Blair J, et al. Radiation exposure time during MBSS: influence of swallowing impairment severity, medical diagnosis, clinician experience, and standardized protocol use. *Dysphagia* 2013;28(1):77–85
- 10 Eckley CA, Fernandes AM. Método de avaliação Otorrinolaringológica da deglutição. *ACTA ORL*. 2005;23:12–16
- 11 Ayoob KT, Duyff RL, Quagliani D. American Dietetic Association (ADA). Food and nutrition misinformation: position of ADA. *J Am Diet Assoc* 2002;102:260–266
- 12 Ott DJ, Hodge RG, Pikna LA, Chen MY, Gelfand DW. Modified barium swallow: clinical and radiographic correlation and relation to feeding recommendations. *Dysphagia* 1996;11(3):187–190
- 13 Tablan OF, Anderson LJ, Arden NH, et al. Centers for Disease Control and Prevention. Guidelines for prevention of nosocomial pneumonia. *MMWR Recomm Rep* 1997;46(RR-1):1–79
- 14 Queiroz MAS, Andrade ISN, Haguette RCB, Haguette EF. Avaliação clínica e objetiva da deglutição em crianças com paralisia cerebral. *Soc Bras Fonoaudiol* 2011;16:210–214
- 15 Furkim AM, Behlau MS, Weckx LL. Avaliação clínica e videofluoroscópica da deglutição em crianças com paralisia cerebral tetraparética espástica. *Arq Neuro-Psiquiatr* 2003;61(3A):611–616
- 16 Vivone GP, Tavares MMM, Bartolomeu RS, Nembr K, Chiappetta ALML. Análise da consistência alimentar e tempo de deglutição em crianças com paralisia cerebral tetraplégica espástica. *Rev CEFAC* 2007;9:504–511
- 17 Levy DS, CRISTOVÃO PW, GABBIS. Protocolo do estudo dinâmico da deglutição por videofluoroscopia. In: Jacobi JS, Levy DS, Silva LMC. *Disfagia: avaliação e tratamento*. Rio de Janeiro: Revinter; 2004:134–52
- 18 Gomes G. Identificação de fatores preditivos de pneumonia aspirativa em pacientes hospitalizados com doença cerebrovascular complicada por disfagiaorofaríngea [dissertation]. Universidade do Paraná: Curitiba; 2001
- 19 Blanco OFS, Aristizábal DS, Pineda AM, et al. Características clínicas y videofluoroscópicas de la disfagia orofaríngea em niños entre um mês y cinco años de vida. *Hospital universitario San Vicente de Paúl, Medellín, Colombia. Iatreia* 2008; 21:13–20
- 20 Macedo-filhoed. Mecanismos protetores da deglutição. In: Jacobi JS, Levy DS, Silva LMC. *Disfagia, avaliação e tratamento*. 2004: 18–25
- 21 Rogers B, Arvedson J, Buck G, Smart P, Msall M. Characteristics of dysphagia in children with cerebral palsy. *Dysphagia* 1994;9(1): 69–73
- 22 Weir K, McMahon S, Barry L, Ware R, Masters IB, Chang AB. Oropharyngeal aspiration and pneumonia in children. *Pediatr Pulmonol* 2007;42(11):1024–1031
- 23 Manrique D, Melo ECM, Buhler RB. Alterações nasofibrolaringoscópicas da deglutição na encefalopatia crônica não-progressiva. *J Pediatr* 2002;77:67–70
- 24 Fischer GB, Pil ZW. Síndromes aspirativas pulmonares em pediatria. In: Jacobi JS, Levy DS, Silva LMC. *Disfagia: avaliação e tratamento*. Rio de Janeiro: Revinter; 2004:123–33
- 25 Costa MMB, Novaj LL, Canevaro LV. Efeito da filtração adicional nas doses de radiação e na qualidade das imagens nos exames videofluoroscópicos. *Radiol Bras* 2009;42:379–387
- 26 International Commission on Radiological Protection. The 2007 Recommendations of the International Commission on Radiological Protection. Available at: <http://www.icrp.org/publication.asp?id=ICRP%20Publication%20103>. Accessed on Aug 5, 2013