

Association between deep neck space abscesses and internal carotid artery narrowing in pediatric patients

Betül Emine DERİNKUYU^{1*}, Öznur BOYUNAĞA¹, Meltem POLAT², Çağrı DAMAR¹, Anıl TAPISIZ AKTAŞ²,
Ayşe Gül ALIMLI¹, Çiğdem ÖZTUNALI¹, Soner Sertan KARA², Murat UÇAR³, Hasan TEZER²

¹Department of Pediatric Radiology, Faculty of Medicine, Gazi University, Ankara, Turkey

²Department of Pediatric Infectious Diseases, Faculty of Medicine, Gazi University, Ankara, Turkey

³Department of Radiology, Faculty of Medicine, Gazi University, Ankara, Turkey

Received: 31.07.2017 • Accepted/Published Online: 14.09.2017 • Final Version: 19.12.2017

Background/aim: Our aim was to interpret the effects of deep neck space abscesses on the adjacent carotid artery according to abscess location, as well as to determine narrowing by calculating the mean stenosis ratios.

Materials and methods: Neck computed tomography scans and clinical data of 45 children with neck abscesses were evaluated retrospectively for abscess location and internal carotid artery narrowing. The lumen areas of the carotid arteries were measured from standard levels, and stenosis ratios were calculated with two different techniques. The mean stenosis ratios of each group according to abscess location were then compared with the control group.

Results: Among the 45 abscesses included in the study, 51.1% (n = 23/45) were located in the peritonsillar region, 37.8% (n = 17/45) were located in the parapharyngeal-lateral retropharyngeal space, and 11.1% (n = 5/45) were in the midline retropharyngeal space. We found a statistically significant difference between the mean stenosis ratios of the ipsilateral side of the parapharyngeal-lateral retropharyngeal abscesses and the control group (P < 0.01).

Conclusion: The children with parapharyngeal-lateral retropharyngeal abscesses all had narrowing in the adjacent carotid lumen to some degree. Although most of the patients had no clinical symptoms, radiologists have to be aware of this arterial complication to prevent further progress and fatal complications.

Key words: Deep neck abscess, computed tomography, mean stenosis ratio, internal carotid artery

1. Introduction

In pediatric patients, deep neck space infections are generally caused by suppurative and perforation of pharyngeal lymph nodes after an infection in Waldeyer's ring, the middle ear, or the upper respiratory tract. Deep neck space infections develop inside the potential spaces formed by the layers of the cervical fascia, which is a serious but often underestimated problem since it may be clinically difficult to determine whether there is an abscess or not (1-4). Imaging plays an essential role in defining the source, the location, and the extension of the infection. Contrast-enhanced computed tomography (CT) plays an important role for accurate assessment in deep neck space infections in emergency conditions (5). If the severity of the infection is not determined quickly, the infection may progress and can cause life-threatening complications, including mediastinitis, empyema, jugular vein thrombophlebitis, sepsis, or airway obstruction.

Generally, complications occur with the extension of the infection to the adjacent structures or as a result of mass effect (1-4). Vascular involvement is not common but, if it happens, venous complications can generally be seen. Arterial complications from head and neck infections are rare but can be life-threatening, such as internal carotid artery (ICA) pseudoaneurysm-rupture or ICA narrowing-occlusion (3,6,7). The purpose of this study is to interpret the effects of deep neck space abscesses on the adjacent ICA according to abscess location, as well as to determine narrowing by calculating mean stenosis ratios.

2. Materials and methods

2.1. Case identification and data collection

This retrospective study was reviewed and approved by our institutional research ethics board committee. All studies were performed for clinical indication in line with local ethics guidelines and standard departmental imaging

* Correspondence: betulemineyildiz@gmail.com

protocols. A radiologist with 10 years of experience retrospectively evaluated the neck CT data of 86 children who had been treated and/or followed with a diagnosis of deep neck space infection between September 2011 and September 2015 from our hospital's PACS system. Forty-one patients were excluded. The exclusion criteria were nonexistence of deep neck space abscess and/or existence of cellulites and/or edema, poor imaging due to motion artifact, and unavailability of radiological or clinical data. The physical examination and clinical findings were found in the patients' medical records.

2.2. Technique

CT studies were done after intravenous contrast agent administration of 1.5 mL/kg of nonionic contrast material via automatic injector. CT studies were performed without anesthesia in the supine position, completely covering the area of suspected pathology in the neck from the skull base to the thoracic upper mediastinum with a 16-section multidetector row CT scanner (Bright Speed, GE Healthcare). The CT scanning parameters were 150 mA, 120 kV, and a 512×512 matrix with 1-mm slice thickness and 1-s rotation time. Images were acquired in the axial plane, the multiplanar was reformatted, and volume-rendering or 3D images were obtained in addition to axial ones. Total imaging time ranged from 3 to 4 min.

Deep neck space abscesses were diagnosed based on the CT findings. A retrospective review was performed by a pediatric radiologist for the presence of any abscess considered present when an area of low density with peripheral enhancement was seen. Approximately 45 patients with deep neck abscesses were included in the study. The pediatric radiologist assessed the location of the abscess on the CT images. The location of the abscess was then distinguished as: 1, peritonsillar; 2, parapharyngeal-lateral retropharyngeal; or 3, midline retropharyngeal abscess.

Examinations were reviewed and measurements were done in a random manner at the same workstation (Advantage Windows 4.4, GE Healthcare) by a pediatric radiologist. The pediatric radiologist measured the areas of the ICA lumen in the ipsilateral and contralateral sides of the abscess at its largest diameter using source axial plane CT images by freehand drawing separately for every patient.

The North American Symptomatic Carotid Endarterectomy Trial (NASCET) score was established by angiographic calculation of the ICA stenosis percentage using the following formula (8–10):

$\% \text{ ICA stenosis} = (1 - [\text{narrowest ICA}/\text{normal distal cervical ICA}]) \times 100$

The common carotid formula was quite different from the NASCET, as follows (8–10):

$\% \text{ ICA stenosis} = (1 - [\text{narrowest ICA}/\text{distal cervical CCA}]) \times 100$

In these two formulas, the diameters of the carotid arteries were used. We modified these two formulas by using the measurements of the lumen areas of the carotid arteries instead of the diameter to be able to calculate the stenosis ratios more accurately.

To calculate the stenosis ratio according to our modified NASCET and modified common carotid formulas, the areas of the distal CCA and proximal ICA lumen at the level of 1 cm below and above the carotid bifurcation were measured by freehand drawing in both sides, as well. The area measurements of the CCA and ICA lumen that were done from contralateral sides of the peritonsillar and parapharyngeal-lateral retropharyngeal abscesses were used as the control group.

2.3. Statistical analysis

Mean stenosis ratios of the carotid arteries were calculated for every patient bilaterally according to our modified NASCET and modified common carotid formulas. The statistical data of the patients were grouped as follows: Group 1, ipsilateral side of the peritonsillar abscess; Group 2, ipsilateral side of the parapharyngeal-lateral retropharyngeal abscess; Group 3, midline retropharyngeal abscess in both sides; and the control group (Group 4), contralateral sides of the peritonsillar and parapharyngeal-lateral retropharyngeal abscess. Statistical analyses were performed using SPSS software (Chicago, IL, USA). The statistical data of the mean stenosis ratios of each group were presented as mean $\pm$ standard deviation (SD). We then compared each group with the control group. A value of $P < 0.05$ was accepted as statistically significant.

3. Results

All of the 45 patients included in the study were confirmed as having a deep neck space abscess by CT. Among the 45 patients included in the study, 60% ($n = 27/45$) were male and 40% ($n = 18/45$) were female with an age range of 1–18 years and a mean age of 9.8 years. The age distributions were as follows: 14 patients (31.1%) were younger than 6 years old, 16 patients (35.6%) were from 6 to 12 years old, and 15 patients (33.3%) were from 12 to 18 years old. Among the 45 abscesses, 48.9% ($n = 22/45$) of the collections were located in the right side, 40% ($n = 18/45$) of the collections were located in the left side, and 11.1% ($n = 5/45$) collections were in the midline of the retropharyngeal space lying down to the upper mediastinum. Among the 45 abscesses, 51.1% ($n = 23/45$) were located in the peritonsillar region, 37.8% ($n = 17/45$) were located in the parapharyngeal-lateral retropharyngeal spaces, and 11.1% ($n = 5/45$) were in the medial retropharyngeal space, formerly called the danger zone.

In Group 1, among the 23 abscesses in the peritonsillar region, the mean stenosis ratio of the ipsilateral carotid measurements was 16.9% (SD = 7.1) according to the

modified NASCET score and 32.8% (SD = 9.3) according to the modified common carotid formula (CCF) (Figure 1; Table).

In Group 2, among the 17 abscesses in the parapharyngeal–lateral retropharyngeal spaces, the mean stenosis ratio of the ipsilateral carotid measurements was 49.1% (SD = 13.2) according to the modified NASCET score and 62.7% (SD = 14.4) according to the modified CCF (Figure 2; Table).

In Group 3, among the 5 abscesses in the midline retropharyngeal space, the mean stenosis ratio of the bilateral carotid measurements was 20.4% (SD = 8.3) according to the modified NASCET score and 36.8% (SD = 12.3) according to the modified CCF (Figure 3; Table).

In Group 4, the control group, among the 40 contralateral carotid measurements of the peritonsillar and parapharyngeal–lateral retropharyngeal abscesses, the mean stenosis ratio was 14.1% (SD = 7.6) according to the modified NASCET score and 30.2% (SD = 8.9) according to the modified CCF (Table).

There was no statistically significant difference between Group 1 and the control group according to the modified NASCET score ($P > 0.1$) and the modified CCF ($P > 0.2$). On the other hand, the carotid measurements of Group 2 had significantly higher stenosis ratios than the control

group according to both the modified NASCET score and modified CCF ($P < 0.01$). Lastly, there was a prominent statistical difference between Group 3 and the control group according to the modified NASCET score ($P < 0.05$), whereas there was no statistically significant difference between Group 3 and the control group according to the modified CCF ($P > 0.05$) (Table).

Among the 45 patients who had deep neck space infection, their neurologic physical examinations (cranial nerve and mental status exam, cerebellar tests, reflexes, and sensory-motor functions) were, except for one patient, all normal according to their medical records. The patient in question had a right-side lateral retropharyngeal abscess with ipsilateral internal carotid artery narrowing. In the medical records, this patient had slight lower extremity weakness during physical examination. On brain magnetic resonance imaging (MRI), the patient had focus of restricted diffusion in the right periventricular region (Figure 2). In the follow-up, the patient recovered without any sequela after heparin therapy.

4. Discussion

The most remarkable result of our study is that we found a statistically significant difference in the mean stenosis ratios of the ipsilateral side of the parapharyngeal–lateral retropharyngeal abscesses and the ones found in the control group. This narrowing may be related to the involvement of the wall of the vessel by the inflammatory process itself. This process could be arteritis that is an inflammation of the walls of arteries, usually as a result of infection or as a result of a response of the autoimmune system. It could cause fatal complications such as thrombosis, sepsis, pseudoaneurysm, or perforation secondary to the wall weakening (3,7,11,12). In addition, the closest space to the carotid space is the parapharyngeal and the lateral retropharyngeal spaces in the neck, which may also explain this result. The abscess in the closest space causes more narrowing than the ones located farther away.

In our study, we found that there was no significant difference in the mean ratios between the ipsilateral side of the peritonsillar abscesses and the ones found in the control group. This result could be explained by the fact that the peritonsillar space is relatively farther away from the carotid space than the others. Generally, a peritonsillar abscess is a relatively benign condition. The statistical significance in the mean stenosis ratios between the midline retropharyngeal abscess and the ones found in the control group was quite dissimilar between modified NASCET and modified CCF values. According to the modified NASCET score, the P -value was $P < 0.05$, whereas according to the modified CCF the P -value did not reach conventional levels of statistical significance ($P = 0.058$). However, there was a clear tendency to significance (Table).

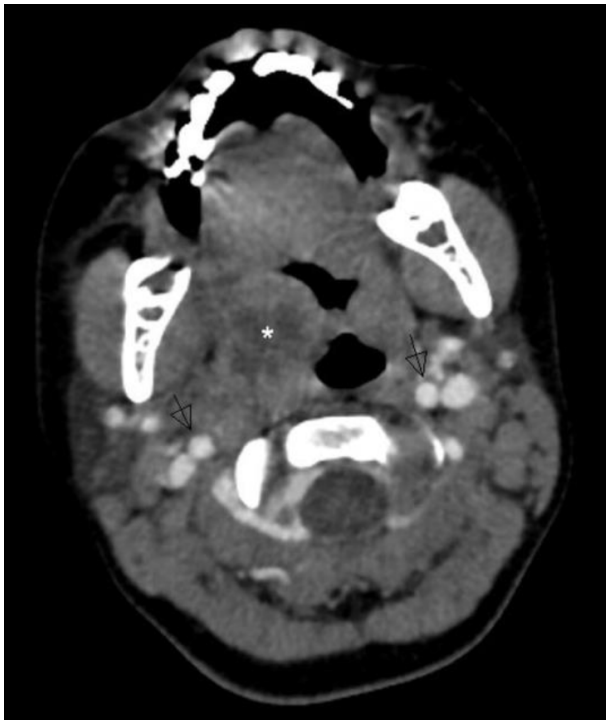


Figure 1. Contrast enhanced neck CT of a 7-year-old girl with a right peritonsillar abscess (asterisk). The internal carotid arteries are similar in caliber in the ipsilateral and contralateral sides (black arrows).

Table. Mean stenosis ratios of the carotid arteries in the different groups.

	N	mNASCET %	P	mCCF %	P
Group 1 Ipsilateral carotid of peritonsillar abscess	23	16.9 ± 7.1%	P > 0.1	32.8 ± 9.3%	P > 0.2
Group 2 Ipsilateral carotid of parapharyngeal–lateral retropharyngeal abscess	17	49.1 ± 13.2%	P < 0.01	62.7 ± 14.4%	P < 0.01
Group 3 Bilateral carotid of medial retropharyngeal abscess	10 (5×2)	20.4 ± 8.3%	P < 0.05	36.8 ± 12.3%	P = 0.058
Group 4 (control) Contralateral carotid of Group 1 and 2	40	14.1 ± 7.6%		30.2 ± 8.9%	

N: Number; mNASCET: modified North American Symptomatic Carotid Endarterectomy Trial; mCCF: modified common carotid formula.

According to this result, the midline retropharyngeal abscess also could cause carotid artery narrowing in both sides but not as significantly as the parapharyngeal–lateral retropharyngeal abscess.

Posterior to the retropharyngeal space is the danger space, separated from the retropharyngeal space by the alar fascia. Infection in the danger space most commonly occurs when an abscess in the retropharyngeal space ruptures through the alar fascia (13–15). On CT, it may be difficult to differentiate midline retropharyngeal abscesses from danger space abscesses. The midline retropharyngeal abscesses may result in an unimpeded potential craniocaudal spread from the base of skull to the mediastinum behind the esophagus. This can lead to sepsis or airway obstruction, both of which are life-threatening emergencies. In pediatric patients, the lateral retropharyngeal lymph nodes may suppurate after an infection and then become an abscess. According to our study, we could say that in this instance the lateral retropharyngeal abscess is closest to the carotid artery and can cause arteritis and carotid artery narrowing. Meanwhile, the lateral retropharyngeal abscess may rupture into the danger space and could cause a retropharyngeal midline abscess all the way down to the mediastinum. According to this study, besides the midline retropharyngeal abscess, the parapharyngeal–lateral retropharyngeal abscess could also cause a life-threatening emergency because it can cause ipsilateral carotid artery narrowing.

Hudgins et al. reviewed 13 patients with retropharyngeal abscess and ICA narrowing. They found a significant difference in the diameter of the ICA lumen between the ipsilateral and the contralateral sides of the retropharyngeal abscess (3). In that study, Hudgins et al. measured the diameter of the ICA in one direction, whereas in our study we measured the area of the ICA lumen completely by freehand drawing. Ide et al. reported a case that represented circumferential enhancement of the carotid

artery wall and narrowing of the carotid artery lumen on contrast-enhanced MRI by retropharyngeal abscess as an early involvement. In addition, they suggested that the cause of the ICA narrowing may have been related to the vessel spasm or vessel wall inflammation (12). In another case report, Elliott et al. reported a carotid artery occlusion in association with a retropharyngeal abscess. They treated their patient with antibiotherapy and anticoagulation with heparin to prevent any thrombosis of the ICA, although the patient had no neurological symptoms (11). Similarly, in our study, we found statistically significant narrowing in children with parapharyngeal–lateral retropharyngeal abscesses; however, the patients had no neurologic deficit except in the case of one patient. In this patient, who had right lateral retropharyngeal abscess and carotid artery narrowing, there was a focus of restricted diffusion in the right periventricular region. This restricted diffusion area may be secondary to the perfusion defect caused by carotid artery narrowing. The second possibility is that the restricted diffusion area may have been a result of septic emboli. In the beginning, the child exhibited weakness in the neurological exam but, after heparin therapy, the physical exam findings became normal. We can affirm that children tolerate carotid narrowing better clinically than adults, which may be the result of the capability of collateralization of the cerebral vasculature.

Deep neck infection often starts as cellulites of the tissue adjacent to the source of infection. The pharyngeal lymph nodes are in the drainage pathway for tonsillar and adenoid infections, paranasal sinus infections, or ear infections that progress to lymph nodes that become inflamed and enlarged first and then may suppurate. After the rupture of these suppurative pharyngeal lymph nodes into the adjacent neck spaces, it may result in abscess formation. This spread is commonly seen in early childhood (6,14–16). After the childhood period, these pharyngeal lymph nodes atrophy. Deep neck infection is

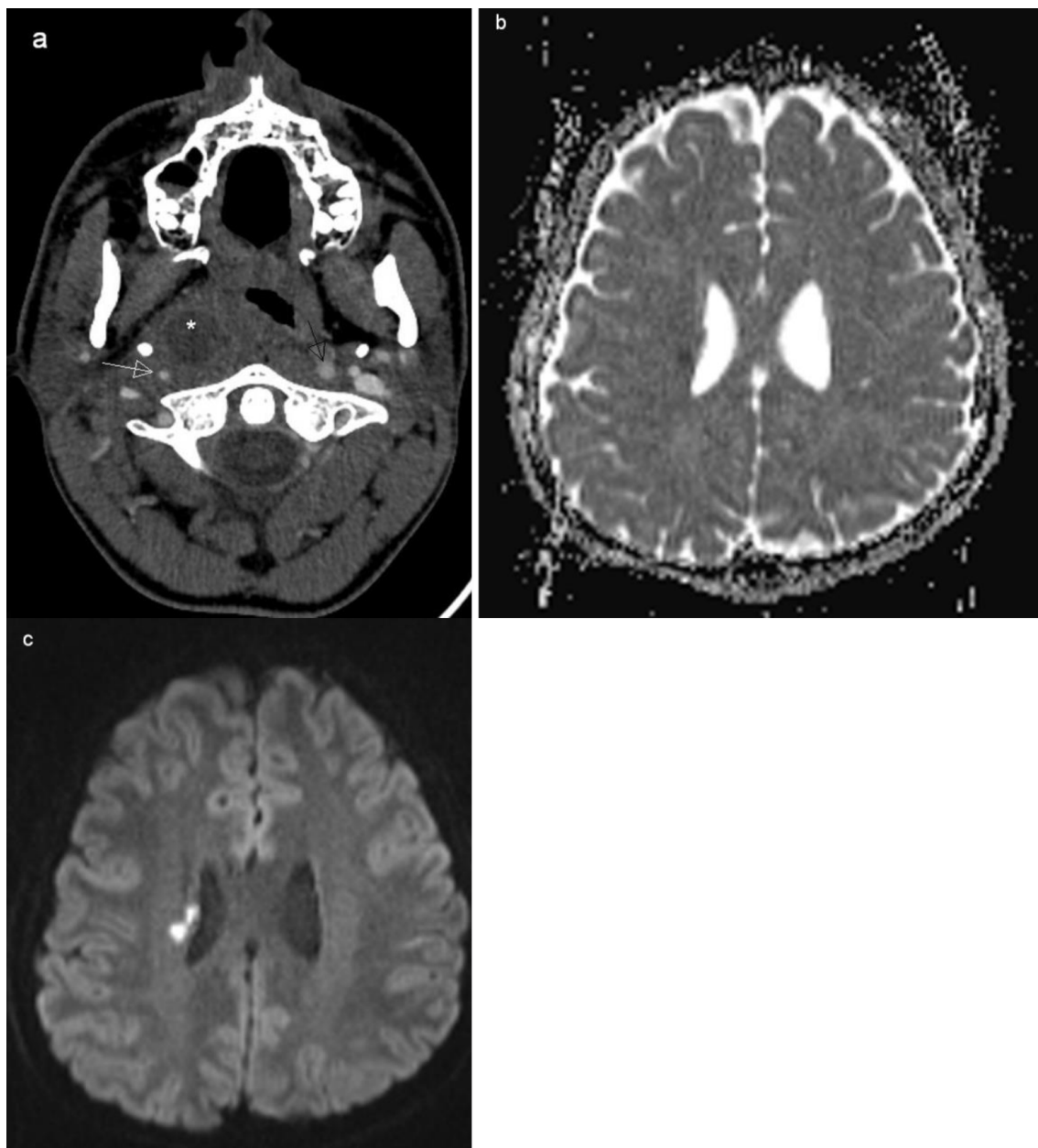


Figure 2. a) Contrast enhanced neck CT in the axial plane of a 10-year-old boy shows a right-sided parapharyngeal-lateral retropharyngeal abscess (asterisk) with a thin enhancing border. Note the internal carotid artery narrowing of the ipsilateral side (white arrow) compared to the contralateral side (black arrow). The ADC map (b) and DWI (c) demonstrate a focus of restricted diffusion area in the right periventricular region.

well known to occur more often in males. It is believed that the strength of the connective tissue between males and females is different. In our study, we observed this hypothesis as having male dominance.

There are some limitations in this study. First of all, this was a retrospective study. We included patients who had routine neck CT examinations. If these CT examinations were performed with CT angiography protocol, the lumen

of the carotid arteries could be measured more accurately. Another limitation of our study is that we could not obtain any brain imaging in order to determine neurologic sequela as a result of ICA narrowing in every patient. In addition, we did not conduct interobserver reliability analysis of the ICA lumen area measurements. Finally, we compared ICA lumen narrowing to the contralateral sides as a control group.

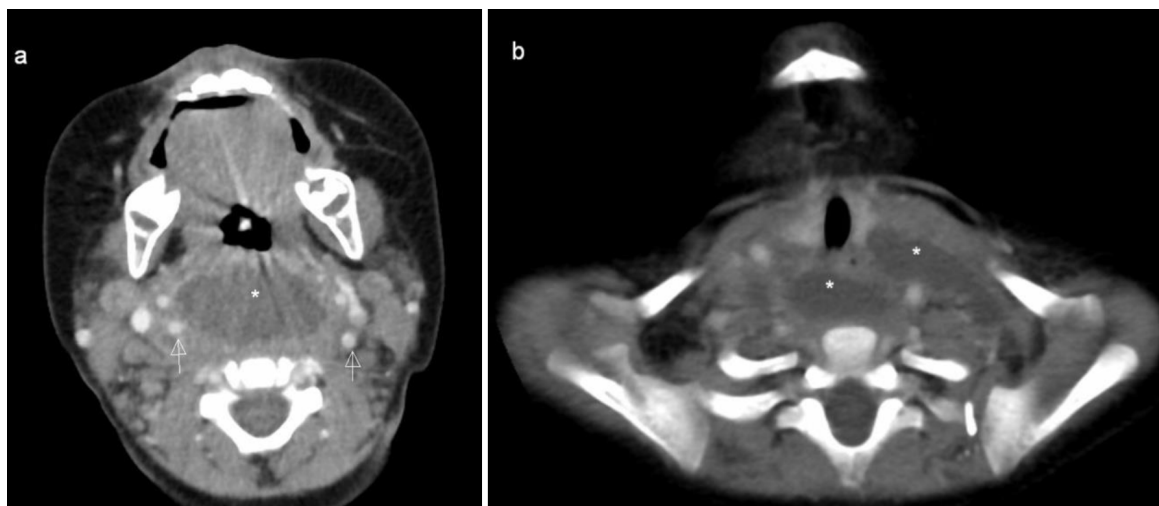


Figure 3. Contrast enhanced neck CT (a, b) of a 1-year-old boy in the axial plane shows a large midline retropharyngeal abscess that goes all the way down to the upper mediastinum (asterisk). The caliber of the internal carotid artery is slightly more reduced in the right side than in the left (white arrows).

In conclusion, we found a statistically significant difference in the mean stenosis ratios of the ipsilateral side of the parapharyngeal–lateral retropharyngeal abscesses. Children with parapharyngeal–lateral retropharyngeal abscesses all had narrowing in the adjacent ICA lumen

to some degree. Although most of the patients had no clinical symptoms, radiologists have to be aware of this arterial complication to prevent its further progress and fatal complications.

References

1. Rana RS, Moonis G. Head and neck infection and inflammation. *Radiol Clin N Am* 2011; 49: 165-182.
2. Chang L, Chi H, Chiu NC, Huang FY, Lee KS. Deep neck infections in different age groups of children. *J Microbiol Immunol* 2010; 43: 47-52.
3. Hudgins PA, Dorey JH, Jacobs IN. Internal carotid artery narrowing in children with retropharyngeal lymphadenitis and abscess. *Am J Neuroradiol* 1998; 19: 1841-1843.
4. Vieira F, Allen SM, Stocks RM, Thompson JW. Deep neck infection. *Otolaryng Clin N Am* 2008; 41: 459-483.
5. Maroldi R, Farina D, Ravanelli M, Lombardi D, Nicolai P. Emergency imaging assessment of deep neck space infections. *Semin Ultrasound CT* 2012; 33: 432-442.
6. Krysl J, Noel de Tilly L, Armstrong D. Pseudoaneurysm of the internal carotid artery: complication of deep neck space infection. *Am J Neuroradiol* 1993; 14: 696-698.
7. Waggie Z, Hatherill M, Millar A, France H, Van Der Merwe A, Argent A. Retropharyngeal abscess complicated by carotid artery rupture. *Pediatr Crit Care Med* 2002; 3: 303-304.
8. European Carotid Surgery Trial Collaborators. MRC European Carotid Surgery Trial: interim results for symptomatic patients with severe (70-99%) or with mild (0-29%) carotid stenosis. *Lancet* 1991; 337: 1235-1243.
9. North American Symptomatic Carotid Endarterectomy Trial Collaborators. Beneficial effect of carotid endarterectomy in symptomatic patients with high-grade carotid stenosis. *N Engl J Med* 1991; 325: 445-453.
10. Rothwell PM, Gibson RJ, Slattery J, Warlow CP. Prognostic value and reproducibility of measurements of carotid stenosis: a comparison of three methods on 1001 angiograms. *Stroke* 1994; 25: 2440-2444.
11. Elliott M, Yong S, Beckenham T. Carotid artery occlusion in association with a retropharyngeal abscess. *Int J Pediatr Otorhi* 2006; 70: 359-363.
12. Ide C, Bodart E, Remacle M, De Coene B, Nisolle JF, Trigaux JP. An early MR observation of carotid involvement by retropharyngeal abscess. *Am J Neuroradiol* 1998; 19: 499-501.
13. Watanabe M, Ohshika Y, Aoki T, Takagi K, Tanaka S, Ogata T. Empyema and mediastinitis complicating retropharyngeal abscess. *Thorax* 1994; 49: 1179-1180.
14. Brook I. Microbiology and management of peritonsillar, retropharyngeal, and parapharyngeal abscesses. *J Oral Maxil Surg* 2004; 62: 1545-1550.
15. Gaglani MJ, Edwards MS. Clinical indicators of childhood retropharyngeal abscess. *Am J Emerg Med* 1995; 13: 333-336.
16. Philpott CM, Selvadurai D, Banerjee AR. Paediatric retropharyngeal abscess. *J Laryngol Otol* 2004; 118: 919-926.