AJNR

The Pharyngolaryngeal Venous Plexus: A Potential Pitfall in Surveillance Imaging of the Neck

P.M. Bunch, R.T. Hughes, E.P. White, J.R. Sachs, B.A. Frizzell and C.M. Lack

AJNR Am J Neuroradiol published online 4 March 2021
http://www.ajnr.org/content/early/2021/03/04/ajnr.A7033

Published March 4, 2021 as 10.3174/ajnr.A7033

The Pharyngolaryngeal Venous Plexus: A Potential Pitfall in Surveillance Imaging of the Neck

P.M. Bunch, R.T. Hughes, E.P. White, J.R. Sachs, B.A. Frizzell, and C.M. Lack

ABSTRACT

BACKGROUND AND PURPOSE: Among patients undergoing serial neck CTs, we have observed variability in the appearance of the pharyngolaryngeal venous plexus, which comprises the postcricoid and posterior pharyngeal venous plexuses. We hypothesize changes in plexus appearance from therapeutic neck irradiation. The purposes of this study are to describe the CT appearance of the pharyngolaryngeal venous plexus among 2 groups undergoing serial neck CTs—patients with radiation therapy–treated laryngeal cancer and patients with medically treated lymphoma—and to assess for changes in plexus appearance attributable to radiation therapy.

MATERIALS AND METHODS: For this retrospective study of 98 patients (49 in each group), 448 contrast-enhanced neck CTs (222 laryngeal cancer; 226 lymphoma) were assessed. When visible, the plexus anteroposterior diameter was measured, and morphology was categorized.

RESULTS: At least 1 plexus component was identified in 36/49 patients with laryngeal cancer and 37/49 patients with lymphoma. There were no statistically significant differences in plexus visibility between the 2 groups. Median anteroposterior diameter was 2.1 mm for the postcricoid venous plexus and 1.6 mm for the posterior pharyngeal venous plexus. The most common morphology was "bilobed" for the postcricoid venous plexus and "linear" for the posterior pharyngeal venous plexus. The pharyngolaryngeal venous plexus and its components were commonly identifiable only on follow-up imaging.

CONCLUSIONS: Head and neck radiologists should be familiar with the typical location and variable appearance of the pharyngolaryngeal plexus components so as not to mistake them for neoplasm. Observed variability in plexus appearance is not attributable to radiation therapy.

ABBREVIATIONS: AP = anteroposterior; PCVP = postcricoid venous plexus; PLVP = pharyngolaryngeal venous plexus; PPVP = posterior pharyngeal venous plexus; RT = radiation therapy; SI = superior-inferior

Laryngeal and hypopharyngeal venous anatomy has been a subject of interest in the anatomic,[1-7] otolaryngologic,[8,9] and radiologic[10-14] literature. Anatomists have consistently identified a rich plexus of veins in the postcricoid and posterior hypopharynx, which has been termed the "pharyngolaryngeal venous plexus" (PLVP).[2,8] The PLVP has been described as larger and better developed in fetal and infant dissections than in those performed in older children and adults.[3,15]

The PLVP can be subdivided (Fig 1) into a ventral portion along the posterior aspect of the cricoid cartilage (termed the "postcricoid venous plexus" [PCVP]), and a dorsal portion along the posterior pharyngeal wall (termed the "posterior pharyngeal venous plexus" [PPVP]).[2,4,7,8,16,17] Historically, the PCVP has received more attention in the literature than the PPVP. The PCVP extends cranially to at least the level of the transverse and oblique arytenoid musculature[5] and drains into the superior laryngeal and lingual veins.[2,4,5] In the otolaryngologic literature, the PCVP (also referred to as the "postcricoid cushion"[8,18]) has been documented to cyclically enlarge with Valsalva during the expiratory phase of an infant's cry.[8] In keeping with the age-related differences of the PLVP noted in the anatomic literature, the postcricoid cushion has been observed on flexible fiber-optic laryngoscopy to be most prominent among infants and to become less noticeable in older children.[8] It has been suggested that the increased PCVP prominence in infants may be mechanically beneficial to protect from aspiration,[4,5] prevent emesis during crying,[4,8] and minimize aerophagia during crying.[7]

Received July 10, 2020; accepted after revision November 24.

From the Department of Radiology (P.M.B., E.P.W., J.R.S., C.M.L.) and Radiation Oncology (R.T.H., B.A.F.), Wake Forest School of Medicine, Winston Salem, North Carolina.

Please address correspondence to Paul M. Bunch, MD, Department of Radiology, Wake Forest School of Medicine, Medical Center Blvd, Winston Salem, NC 27157; e-mail: paul.m.bunch@gmail.com; @pbunchmd
http://dx.doi.org/10.3174/ajnr.A7033

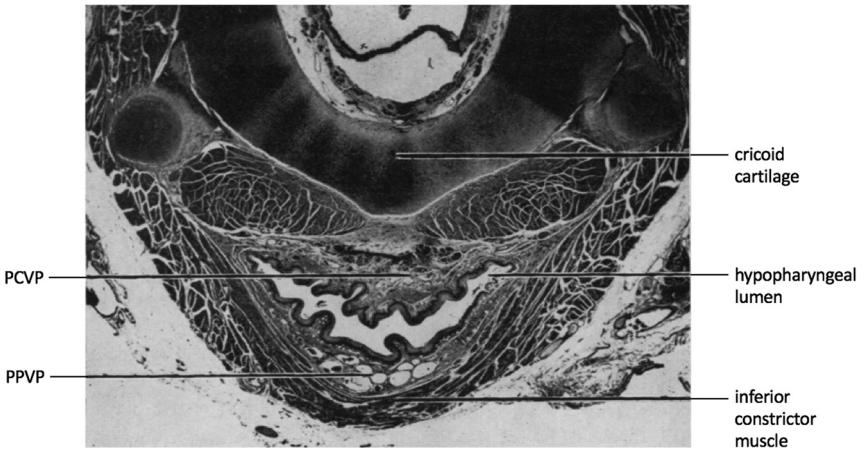

FIG 1. Transverse histopathologic section of the hypopharynx of a full-term fetus at the level of the cricoid cartilage shows the locations of the PCVP and the PPVP. Reproduced from Butler[5] with permission from BMJ Publishing Group Ltd.

Most prior radiologic studies addressing postcricoid anatomy have focused on fluoroscopy.[10-12,14] In such fluoroscopic studies, the PCVP has also been referred to as the "postcricoid impression"[10] and has been emphasized to be a normal finding that should not be mistaken for neoplasm.[11] Descriptions of the CT appearance of the PCVP are lacking in the published literature.

In the anatomic literature, the PPVP is reported to be associated with the posterior pharyngeal wall,[2,16,17] lying between the posterior mucosal surface and the inferior constrictor musculature.[3,5] The PPVP drains into the superficial pharyngeal plexus and subsequently into the internal jugular veins.[3,5] Some authors report the PPVP to be located inferiorly with respect to the PCVP,[16,17] though others describe the PCVP and the PPVP being located at the same level.[5] As is true for the PCVP, descriptions of the CT appearance of the PPVP in the published literature are also lacking.

Head and neck radiologists are accustomed to the typical findings of prior therapeutic neck irradiation, including mucosal hyperenhancement, submucosal edema, and fat reticulation.[19,20] As such, these well-described treatment-related changes do not represent diagnostic dilemmas on surveillance imaging. In our clinical practice, we have observed the PLVP on neck CT examinations performed for head and neck cancer follow-up and noticed variations in PLVP thickness and in PLVP visibility within the same patient on different neck CT examinations. The reasons for this observed variability are unclear, but radiation therapy (RT)-induced vascular changes may play a role. Acute increases in vascular permeability and treatment-related local inflammation may influence the CT appearance of the PLVP in the early post-RT period, whereas endothelial cell proliferation and perivascular fibrosis may alter the CT appearance of the PLVP on later imaging follow-up.[21-23]

We hypothesize that PLVP visibility on neck CT imaging changes as a result of therapeutic neck irradiation. The purposes of this study are to describe the CT appearance of the PLVP and its components (the PCVP and the PPVP) among 2 groups of patients undergoing serial neck CTs (patients with RT-treated laryngeal cancer and patients with chemotherapy-treated lymphoma) and to assess for potential RT-associated effects on PLVP visibility through comparison of the 2 groups.

MATERIALS AND METHODS

Subjects

For this retrospective, Health Insurance Portability and Accountability Act–compliant, institutional review board–approved study, an institutional head and neck cancer data base of 266 patients treated with curative intent for laryngeal cancer was first queried for patients satisfying the following criteria: treated with definitive radiation with or without chemotherapy for laryngeal squamous cell carcinoma (excluded = 111); no other previous therapeutic head and neck irradiation (excluded = 6); no primary or salvage surgical management (excluded = 56); pretreatment baseline neck CT with contrast obtained with images available for review (excluded = 15); and at least 1 post-RT neck CT with contrast obtained with images available for review (excluded = 29). Patients were excluded if diagnostic assessment of the larynx and hypopharynx was precluded by severe artifacts on the pretreatment baseline CT or on all post-RT neck CTs. All potential subjects were treated between 2011 and 2018 with intensity-modulated RT or 3D-conformal RT (in cases of stage I–II glottic cancer). Patient age, patient sex, smoking history, and radiation dose were obtained from the electronic medical record.

After determination of the RT-treated laryngeal cancer cohort meeting all inclusion criteria, an age- and sex-matched cohort of patients with lymphoma with no prior history of therapeutic neck irradiation was selected from a local radiology report data base as a control group who had also undergone serial neck CTs. Patient age, patient sex, and smoking history were obtained from the electronic medical record.

Image Acquisition

Given the retrospective nature of this study, there was variability with respect to CT scanners used to acquire images, as well as specific CT acquisition parameters. However, most neck CT examinations were acquired on a LightSpeed VCT (GE Healthcare) with acquisition parameters of 120 kV(peak), Auto mA (noise index = 6, minimum = 100 mA, maximum = 250 mA), 0.969: 1 pitch, 0.8-second rotation time, 2.5-mm helical section thickness, and 1.25-mm interval. Multiplanar reconstructions were generated, including 2.5-mm axial (20-to 30-cm FOV; "standard" kernel) images. Imaging was performed 90 seconds after the injection of 95 mL of iohexol, 350 mg I/mL (split-bolus technique, 65 mL at 4 mL/s, 30-second pause, 30 mL at 4 mL/s) and spanned the skull base to the thoracic inlet.

Reader Assessment

One fellowship-trained neuroradiologist (with 3 years' subspecialty experience) reviewed the neck CT examination axial 2.5-mm

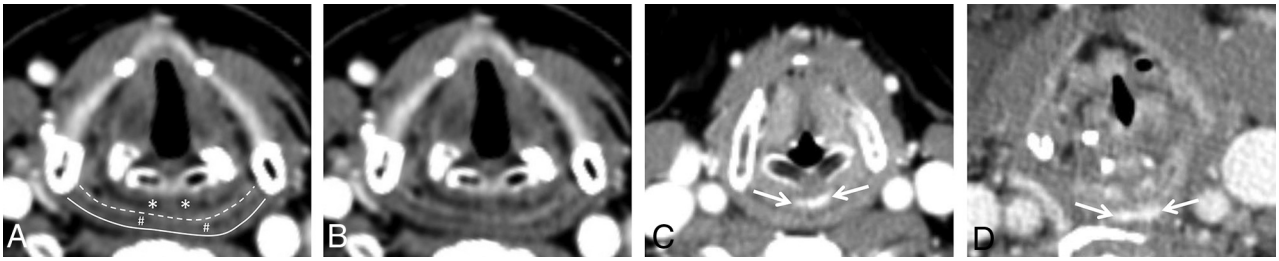

FIG 2. Labeled (*A*) and unlabeled (*B*) axial neck CT images with contrast at the level of the cricoarytenoid joints in a patient without visible PLVP demonstrate the expected locations of the PCVP (*asterisk, A*) between the larynx anteriorly and the hypopharyngeal mucosa (*dashed line, A*) posteriorly, and the PPVP (*pound sign, A*) between the hypopharyngeal mucosa anteriorly and the inferior constrictor musculature (*solid line, A*) posteriorly. Axial neck CT images with contrast in 2 additional patients (*C* and *D*) demonstrate visible PCVP (*arrows, C*) and visible PPVP (*arrows, D*).

Table 1: Characteristics of the study groups

	Laryngeal Cancer	Lymphoma	*P*-Value
Sex			
Male	33 (67%)	33 (67%)	1.00
Female	16 (33%)	16 (33%)	
Age (yr)			
Mean [SD]	58.9 [11.0]	58.9 [11.1]	1.00
Minimum	25	25	
Maximum	83	84	
Smoking history			
Yes	47 (96%)	26 (53%)	<.001
No	2 (4%)	23 (47%)	
Radiation dose (Gy)			
Median	70.0	NA	
Minimum	64.0	NA	
Maximum	70.2	NA	
Neck CTs			
Total	222	226	
Per patient (mean) (SD)	4.5 (2.8)	4.6 (2.7)	.88
Minimum	2	2	
Maximum	16	14	
Months of CT follow-up[a]			
Total	1005	1835	
Mean (SD)	20.5 (13.5)	37.4 (31.4)	<.001
Minimum	4	1	
Maximum	59	162	

Note:—NA indicates not applicable.
[a] For patients with laryngeal cancer, follow-up ended when either no more neck CTs were available or the patient underwent salvage laryngectomy.

soft-tissue kernel images to determine the visibility of the PLVP and its components, the PCVP and the PPVP.

The PCVP was defined as "visible" if tubular or curvilinear submucosal enhancement matching the contrast attenuation of adjacent veins was located posterior to the laryngeal mucosa and anterior to the hypopharyngeal mucosa (Fig 2). The PPVP was defined as visible if tubular or curvilinear submucosal enhancement matching the contrast attenuation of adjacent veins was located posterior to the hypopharyngeal mucosa and anterior to the inferior constrictor musculature (Fig 2). The PLVP was defined as visible if either the PCVP or the PPVP was visible.

When visible, the PCVP and PPVP anteroposterior (AP) diameters and superior-inferior (SI) extent were measured in millimeters. The SI level (eg, cricoid cartilage, arytenoid cartilage, supra-arytenoid) at which the PCVP and PPVP appeared thickest was also recorded. When both the PCVP and the PPVP were visible in the same patient, the relative SI position of the PPVP with respect to the PCVP was documented. In addition, a qualitative, descriptive assessment of PCVP and PPVP morphology on axial CT images was performed with the goal of morphologic categorization.

Statistical Analysis

Descriptive analyses were performed using absolute and relative frequencies for categoric variables and mean or median for normally and non-normally distributed continuous variables, respectively. The Fisher exact test was used to compare proportions, 1-way analysis of variance was used to compare normally distributed continuous variables, and the Wilcoxon rank sum test was used to compare non-normally distributed continuous variables. Analyses were performed with JMP, Version 14 (SAS Institute), and a P value $< .05$ indicated a statistically significant difference.

RESULTS

Subjects

A total of 49 patients with post-RT laryngeal cancer (222 neck CTs) met all inclusion criteria and formed the study cohort for which 49 age- and sex-matched patients with medically-treated lymphoma (226 neck CTs) were selected to serve as controls. Characteristics of the 2 study groups are provided in Table 1.

Reader Assessment

The PLVP was visible on at least 1 neck CT in 36/49 (73%) patients with laryngeal cancer and in 37/49 (76%) patients with lymphoma (P = 1.00). The PLVP was identifiable on baseline neck CT in 21/49 (43%) patients with laryngeal cancer and identifiable on initial neck CT in 22/49 (45%) patients with lymphoma (P = 1.00). Among patients with laryngeal cancer, the PLVP was visible on at least 1 post-RT neck CT in 34/49 (69%) patients and identifiable on 90/173 (52%) of all post-RT neck CTs. Among patients with lymphoma, the PLVP was visible on at least 1 follow-up neck CT in 36/49 (73%) patients (P = .82) and identifiable on 108/177 (61%) of all follow-up neck CTs (P = .11).

For both the laryngeal cancer and lymphoma cohorts, PLVP visibility on the baseline examination predicted PLVP visibility on at least 1 follow-up neck CT: Nineteen of 21 (91%) patients with laryngeal cancer with PLVP visible at baseline exhibited PLVP on at least 1 post-RT neck CT compared with 15/28 (54%) patients with no visible PLVP at baseline (P = .011), and 21/22 (95%) patients with lymphoma with PLVP visible on initial neck CT exhibited PLVP on at least 1 follow-up neck CT compared

Table 2: Visibility of PLVP within the study groups with respect to patient characteristics

	Laryngeal Cancer			Lymphoma		
	PLVP Visible?					
	Yes	No	*P*	Yes	No	*P*
Sex						
Male	23	10	.50	23	10	.29
Female	13	3		14	2	
Age (yr)						
Mean [SD]	58.4 [11.5]	60.3 [10.0]	.60	59.3 [11.6]	57.6 [9.6]	.64
Smoking history						
Yes	34	13	1.00	17	9	.10
No	2	0		20	3	
Radiation dose (Gy)						
Median (range)	70.0 (64.0–70)	70.0 (65.3–70.2)	.26	NA	NA	NA

Note:—NA indicates not applicable.

Table 3: Visibility of PCVP within the study groups with respect to patient characteristics

	Laryngeal Cancer			Lymphoma		
	PCVP Visible?					
	Yes	No	*P*	Yes	No	*P*
Sex						
Male	20	13	.36	23	10	.29
Female	12	4		14	2	
Age (yr)						
Mean [SD]	57.3 [10.9]	61.9 [10.8]	.17	59.3 [9.6]	57.6 [11.6]	.64
Smoking history						
Yes	30	17	.54	17	9	.10
No	2	0		20	3	
Radiation dose (Gy)						
Median (range)	70.0 (64.0–70)	70.0 (65.3–70.2)	.57	NA	NA	NA

Note:—NA indicates not applicable.

with 15/27 (56%) patients without visible PLVP on initial imaging ($P = .002$).

Among patients with laryngeal cancer and lymphoma with a visible PLVP, the frequency with which the PLVP was identifiable in each patient ranged from 15% to 100% (median, 67%). Both the PCVP and the PPVP were visible in 34/73 (47%) patients, only the PCVP was visible in 35/73 (48%), and only the PPVP was visible in 4/73 (5%). When both the PCVP and the PPVP were visible in the same patient, the PPVP was located below the level of the PCVP in 30 patients (88%), at the level of the PCVP in 3 patients (9%), and above the level of the PCVP in 1 patient (3%).

There was no statistically significant association between PLVP visibility and any of the studied patient factors (Table 2).

The PCVP was visible on at least 1 neck CT in 32/49 (65%) patients with laryngeal cancer and in 37/49 (76%) patients with lymphoma ($P = .38$). The PCVP was identifiable on baseline neck CT in 18/49 (37%) patients with laryngeal cancer and identifiable on initial neck CT in 20/49 (41%) patients with lymphoma ($P = .84$). Among patients with laryngeal cancer, the PCVP was visible on at least 1 post-RT neck CT in 30/49 (61%) patients and identifiable on 87/173 (50%) post-RT neck CTs. Among patients with lymphoma, the PCVP was visible on at least 1 follow-up neck CT in 36/49 (73%) patients ($P = .28$) and identifiable on 98/177 (55%) of all follow-up neck CTs ($P = .39$).

For both the laryngeal cancer and lymphoma cohorts, PCVP visibility on the baseline examination predicted PCVP visibility on at least 1 follow-up neck CT: Sixteen of 18 (89%) patients with laryngeal cancer with PCVP visible at baseline exhibited visible PCVP on at least 1 post-RT neck CT compared with 14/31 (45%) patients with no visible PCVP at baseline ($P = .003$), and 19/20 (95%) patients with lymphoma with PCVP visible on initial neck CT exhibited PCVP on at least 1 follow-up neck CT compared with 17/29 (59%) patients without visible PCVP on initial imaging ($P = .007$).

Among patients with laryngeal cancer and lymphoma with visible PCVP, the frequency with which the PCVP was identifiable in each patient ranged from 17% to 100% (median 64%). There was no statistically significant association between PCVP visibility and any of the studied patient factors (Table 3).

When visible, the maximum AP diameter of the PCVP ranged from 0.9 to 5.0 mm (median, 2.1). The PCVP maximum AP diameter increased on at least 1 follow-up neck CT relative to initial imaging in 53/69 (77%) patients, and the PCVP thickness was decreased on all follow-up neck CTs relative to initial imaging in 16/69 (23%) patients. In 1 patient with laryngeal cancer, the prominent post-RT PCVP on follow-up imaging was described by the interpreting radiologist as suspicious for progressive neoplasm (Fig 3); however, the PCVP was confirmed with 22 months of follow-up imaging. The SI extent of PCVP ranged from 2.5 to 26.5 mm (median, 10 mm).

The PCVP appeared thickest at the level of the cricoid cartilage in 14/69 (20%) patients, at the level of the arytenoid cartilage

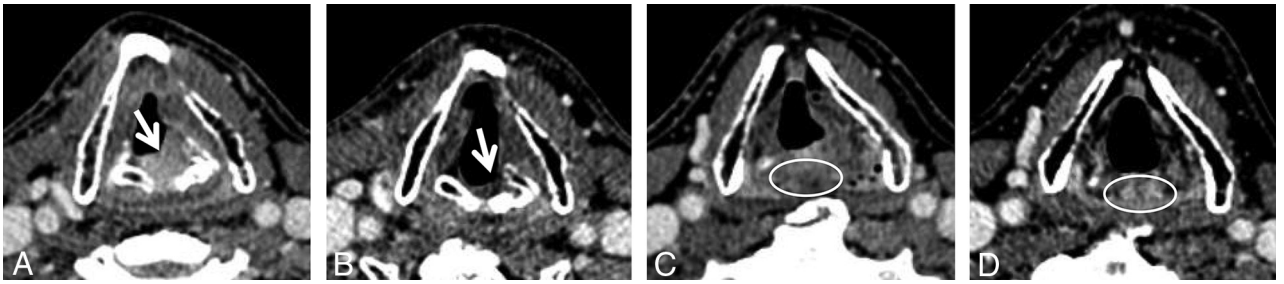

FIG 3. Axial contrast-enhanced neck CT images obtained before (*A* and *C*) and after (*B* and *D*) definitive radiation therapy for laryngeal squamous cell carcinoma (*arrow, A*). Posttreatment images demonstrate a substantial decrease in size of the treated tumor (*arrow, B*) as well as prominent PCVP (*circle, D*) that was not definitively identifiable on the baseline pretreatment neck CT (*circle, C*). The prominent PCVP (*circle, D*) was described as suspicious for progressive neoplasm but confirmed to be vascular after 22 months of imaging follow-up.

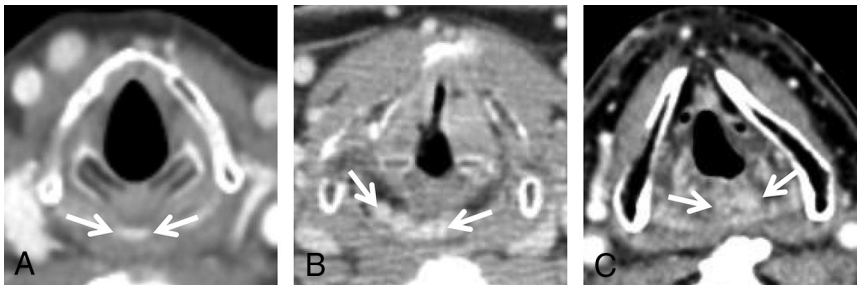

FIG 4. Axial contrast-enhanced neck CT images obtained in 3 different patients demonstrate representative images of the PCVP (*arrows, A–C*) at the cricoid cartilage level (*A*), the arytenoid cartilage level (*B*), and the supra-arytenoid level (*C*).

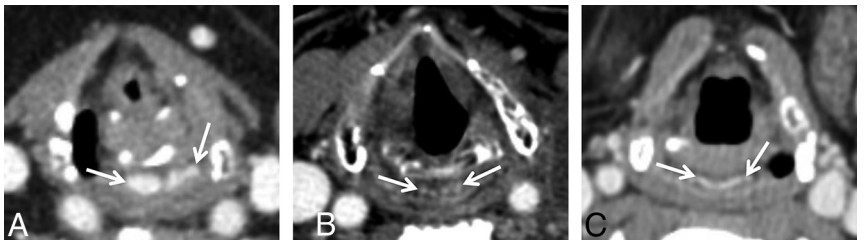

FIG 5. Axial contrast-enhanced neck CT images in 3 different patients demonstrate representative examples of bilobed (*arrows, A*), dot-dash (*arrows, B*), and linear (*arrows, C*) PCVP morphology.

in 21/69 (30%) patients, and at a supra-arytenoid level in 34/69 (49%) patients (Fig 4).

Qualitative assessment of the PCVP appearance resulted in the following morphologic categories (Fig 5): bilobed (n = 31), linear (thin or thick) (n = 14), and dot-dash (n = 19). Five patients exhibited a combination of these morphologies depending on the axial section level. No morphologic category changes were observed between initial and follow-up neck CTs.

The PPVP was visible on at least 1 neck CT in 17/49 (35%) patients with laryngeal cancer and in 21/49 (43%) patients with lymphoma (P = .53). The PPVP was identifiable on baseline neck CT in 6/49 (12%) patients with laryngeal cancer and identifiable on initial neck CT in 10/49 (20%) patients with lymphoma (P = .41). Among patients with laryngeal cancer, the PPVP was visible on at least 1 post-RT neck CT in 17/49 (35%) patients and identifiable on 42/173 (24%) post-RT neck CTs. Among patients with lymphoma, the PPVP was visible on at least 1 follow-up neck CT in 20/49 (41%) patients (P = .68) and identifiable on 53/177 (30%) of all follow-up neck CTs (P = .28).

For both the laryngeal cancer and lymphoma cohorts, PPVP visibility on the baseline examination predicted PPVP visibility on at least 1 follow-up neck CT: Six of 6 (100%) patients with laryngeal cancer with PPVP visible at baseline exhibited visible PPVP on at least 1 post-RT neck CT compared with 11/43 (26%) patients with no visible PPVP at baseline ($P < .001$); and 9/10 (90%) patients with lymphoma with PPVP visible on initial neck CT exhibited PPVP on at least 1 follow-up neck CT compared with 10/39 (26%) patients without visible PPVP on initial imaging ($P < .001$).

Among patients with laryngeal cancer and lymphoma with visible PPVP, the frequency with which the PPVP was identifiable in each patient ranged from 15% to 100% (median, 50%). Among patients with lymphoma, the PPVP was more likely visible among women (P = .01). A significant difference was also observed between the mean age of patients with lymphoma with visible PPVP (62.6 years) and the mean age of patients with lymphoma without visible PPVP (56.1 years; P = .04). Otherwise, there were no statistically significant associations between PPVP visibility and any of the studied patient factors (Table 4).

When visible, the maximum AP diameter of the PPVP ranged from 0.9 to 4.0 mm (median 1.6). The PPVP maximum AP diameter increased on at least 1 follow-up neck CT relative to baseline imaging in 31/38 (82%) patients, and the PPVP thickness was decreased on all follow-up neck CTs relative to baseline imaging in 7/38 (18%) patients. In no cases were prominent PPVPs on follow-up imaging described by the interpreting radiologist as

Table 4: Visibility of PPVP within the study groups with respect to patient characteristics

	Laryngeal Cancer			Lymphoma		
	PPVP Visible?					
	Yes	No	*P*	Yes	No	*P*
Sex						
Male	12	21	1.00	10	23	.01
Female	5	11		11	5	
Age (yr)						
Mean [SD]	59.0 [13.9]	58.8 [9.3]	.96	62.6 [10.9]	56.1 [10.6]	.04
Smoking history						
Yes	16	31	1.00	8	18	.09
No	1	1		13	10	
Smoking history						
Median (range)	70.0 (64.0–70)	70.0 (65.3–70.2)	.06	NA	NA	NA

Note:—NA indicates not applicable.

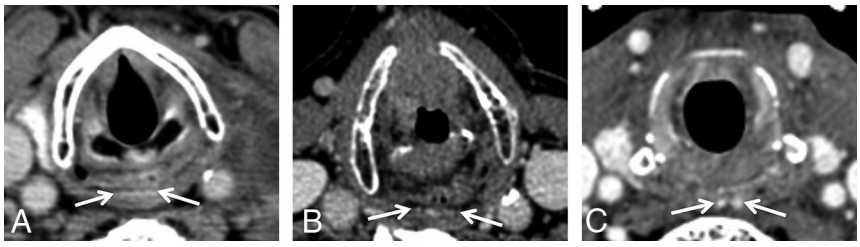

FIG 6. Axial contrast-enhanced neck CT images in 3 different patients demonstrate representative examples of linear (*arrows, A*), dot-dash (*arrows, B*), and bilobed (*arrows, C*) PPVP morphology.

suspicious for progressive neoplasm. The SI extent of PPVP ranged from 5.0 to 26.3 mm (median, 10.0 mm).

The PPVP appeared thickest at the level of the cricoid cartilage in 31/38 (82%) patients, at the level of the arytenoid cartilage in 6/38 (16%) patients, and at a supra-arytenoid level in 1/38 (3%) patients.

Qualitative assessment of the PPVP appearance resulted in the following morphologic categories: linear (thin or thick) (n = 31), dot-dash (n = 5), and bilobed (n = 2) (Fig 6). No morphologic category changes were observed between initial and follow-up neck CTs.

DISCUSSION

Among patients with laryngeal squamous cell carcinoma treated with definitive RT and patients with lymphoma with no history of therapeutic neck irradiation, at least 1 component of the PLVP is commonly identifiable on contrast-enhanced neck CT, though variable in both visibility and thickness between CT examinations. Importantly, in up to 50% of patients in both cohorts with no visible PLVP on initial imaging, at least 1 component could be identified on serial follow-up neck CT. Moreover, the PCVP and PPVP AP thickness measured greatest on a follow-up neck CT examination for greater than 75% of included patients.

We hypothesized that PLVP visibility on neck CT imaging changes because of therapeutic neck irradiation. The results do not support our hypothesis, as there were no significant differences between visibility of the PLVP or its components between the group with RT-treated laryngeal cancer and the group with medically treated lymphoma (control). Although unlikely related to RT-induced inflammation, the factors accounting for the observed variability in plexus visibility within both groups remain uncertain. Some possibilities include hydration status on the day of imaging, the presence or absence of Valsalva during image acquisition, and the higher number of follow-up neck CTs (n = 350) than baseline neck CTs (n = 98) within the 2 cohorts.

Nevertheless, it is important that the radiologist be aware of the existence of such variability as well as of the appearance, location, and common morphologies of the PCVP and PPVP so as not to mistake these normal structures for progressive neoplasm when interpreting surveillance imaging of the neck. As shown in previous anatomic dissections and confirmed in this CT-based study, the PCVP lies in a submucosal location posterior to the laryngeal mucosa and anterior to the hypopharyngeal mucosa between the levels of the supraglottis and the cricoid cartilage. The PPVP lies in a submucosal location posterior to the hypopharyngeal mucosa and anterior to the inferior constrictor muscle, most commonly at the level of the cricoid cartilage but rarely at or above the arytenoid cartilage level.

In our cohort, the most common morphology of the PCVP on axial CT images was bilobed, which is in keeping with earlier anatomic descriptions of the PCVP as 2 longitudinal masses on each side of the midline separated by a gap of 2–6 mm.[5] The most common morphology of the PPVP on axial CT images was linear. PCVP and PPVP longitudinal extent were variable, more commonly 10 mm or greater, and were therefore seen on multiple sequential axial images, though occasionally more focal. Enhancement matching the enhancement of adjacent veins and a tubular rather than masslike configuration would also favor PLVP over neoplasm in the postcricoid region. Alternatively, the PCVP and PPVP could be mistaken for mucositis, particularly among patients who are RT-treated. In our experience, careful attention to the submucosal location of the PCVP and PPVP, immediately anterior and posterior to the hypopharyngeal mucosa, respectively, typically enables differentiation.

There was no correlation between PLVP or PCVP and any studied patient factors. Among patients with lymphoma, PPVP visibility was significantly associated with age and female sex, and these associations were not observed within the group with laryngeal cancer. Although further study may be warranted, we advise caution in ascribing clinical significance to these findings given the small sample size of 21 patients with lymphoma exhibiting visible PPVP.

There are limitations of this study, including small sample size and retrospective design. A single neuroradiologist reader was used, such that interrater reliability was not assessed. It is possible that other neuroradiologists would characterize the visibility and morphology of the PCVP and PLVP differently than what we report, though we have attempted to provide ample illustrative examples in support of our findings. Finally, there were statistically significant differences between the laryngeal cancer and lymphoma groups with respect to smoking history (likely reflecting risk factors for laryngeal cancer) and months of CT follow-up. Although there was no significant association between plexus visibility and smoking history among patients with laryngeal cancer treated with definitive RT, the very few subjects with negative smoking history may influence the accuracy of the statistical comparison between smokers and nonsmokers.

CONCLUSIONS

At least 1 component of the PLVP was identifiable on contrast-enhanced neck CT in most patients with laryngeal cancer and lymphoma, with variable appearance on follow-up imaging compared with baseline. Although the factors contributing to the variable appearance of the PLVP remain uncertain, there is no evidence to support therapeutic neck irradiation as a contributing factor.

In up to 50% of patients with no visible PLVP on initial imaging, the PLVP was identifiable on at least 1 follow-up neck CT and could therefore possibly be confused for neoplasm. Head and neck radiologists should be familiar with the typical location and variable appearance of the PLVP components so as not to mistake this normal vascular structure for progressive neoplasm.

REFERENCES

1. Bourgery J, Jacob N. *Atlas of Human Anatomy and Surgery: The Complete Colored Plates of 1831–1854*. 25th ed. Taschen; 2005
2. von Luschka H. *Der Kehlkopf des Menschen*. H. Laupp; 1871: 147
3. Bimar L, Lapeyre JM. **Recherches sur les veines du pharynx.** *Comp Rend Acad d Sc* 1887;105:825
4. Elze C. **Die venosen Wundernetze der Pars laryngea pharyngis.** *Anat Anz* 1918;51:205–07
5. Butler H. **The veins of the oesophagus.** *Thorax* 1951;6:276–96 CrossRef Medline
6. Tose D, Rodrigues H, DiDio LJ. **The venous architecture of the human pharyngo-esophageal transition.** *Arch Ital Anat Embriol* 1984;89:157–65 Medline
7. Tose D, Rodrigues H, DiDio LJ. **Mucosal and submucosal veins of the human pharyngo-esophageal transition.** *Arch Ital Anat Embriol* 1985;90:9–15 Medline
8. Hoff SR, Koltai PJ. **The "postcricoid cushion": observations on the vascular anatomy of the posterior cricoid region.** *Arch Otolaryngol Head Neck Surg* 2012;138:562–71 CrossRef Medline
9. Haugen TW, Wood WE, Helwig C. **Postcricoid vascular abnormalities: hemangiomas, venous malformations, or anatomic variant.** *Int J Pediatr Otorhinolaryngol* 2012;76:805–08 CrossRef Medline
10. Pitman RG, Fraser GM. **The post-cricoid impression on the oesophagus.** *Clin Radiol* 1965;16:34–39 CrossRef Medline
11. Friedland GW, Filly R. **The postcricoid impression masquerading as an esophageal tumor.** *Am J Dig Dis* 1975;20:287–91 CrossRef Medline
12. Dodds WJ, Stewart ET, Logemann JA. **Physiology and radiology of the normal oral and pharyngeal phases of swallowing.** *AJR Am J Roentgenol* 1990;154:953–63 CrossRef Medline
13. Schmalfuss IM, Mancuso AA, Tart RP. **Postcricoid region and cervical esophagus: normal appearance at CT and MR imaging.** *Radiol* 2000;214:237–46 CrossRef Medline
14. Allen JE, White CJ, Leonard RJ, et al. **Posterior cricoid region fluoroscopic findings: the posterior cricoid plication.** *Dysphagia* 2011;26:272–76 CrossRef Medline
15. Ramaekers D, Mebis J, Geboes K, et al. **Vascularization of the pharyngo-esophageal transition zone** [in Dutch]. *Acta Gastroenterol Belg* 1990;53:376–85
16. Elze C, Beck K. **Die venosen wundernetze der hypopharynx.** *Z Ohrenheilkunde* 1919;185–97
17. Baston O. **Veins of the pharynx.** *Arch Otolaryngol* 1942;36:212–19
18. Hron TA, Kavanagh KR, Murray N. **Diagnosis and treatment of benign pediatric lesions.** *Otolaryngol Clin North Am* 2019;52:657–68 CrossRef Medline
19. Glastonbury CM, Parker EE, Hoang JK. **The postradiation neck: evaluating response to treatment and recognizing complications.** *AJR Am J Roentgenol* 2010;195:W164–71 CrossRef Medline
20. Saito N, Nadgir RN, Nakahira M, et al. **Posttreatment CT and MR imaging in head and neck cancer: what the radiologist needs to know.** *Radiographics* 2012;32:1261–82; discussion 1282–84 CrossRef Medline
21. Hopewell JW, Campling D, Calvo W, et al. **Vascular irradiation damage: its cellular basis and likely consequences.** *Br J Cancer Suppl* 1986;7:181–91 Medline
22. Girinsky T. **Effects of ionizing radiation on the blood vessel wall** [in French]. *J Mal Vasc* 2000;25:321–24 Medline
23. Hall EJ, Giaccia AJ. *Radiobiology for the Radiologist*. 7th ed. Wolters Kluwer Health/Lippincott Williams & Wilkins; 2012