

Appropriateness of Subadventitial Resection for Invasion of the Carotid Artery by Papillary Thyroid Carcinoma

Sueyoshi Moritani¹

Published online: 17 September 2018
© Société Internationale de Chirurgie 2018

Abstract

Background Selection of surgical treatment for patients with papillary thyroid carcinoma (PTC) that includes great vessel invasion is challenging. We investigated the efficacy of tumor excision, with regard to safety of the surgical procedure and prognosis among patients with PTC invasion of the carotid or vertebral artery.

Methods This study is a retrospective review of patients who underwent surgical excision for PTC at our institution, between 1981 and 2010, with 49 patients treated for carotid artery invasion and nine for vertebral artery invasion.

Results Twenty patients with carotid artery invasion receiving initial treatment underwent subadventitial resection. Among 29 relapsing patients with carotid artery invasion, subadventitial resection was performed in 27 and en-block resection and reconstruction in the other two. In patients with carotid artery invasion, locoregional recurrence was identified in 14 patients, with the recurrence specific to the carotid artery in one case and distant recurrence in 15. The 10-year disease-specific survival rate was shorter among relapsing patients (21.7%) than among those receiving an initial treatment (69.3%). At 8 years after surgery, however, the survival rates were comparable between the two groups. Of the nine patients with vertebral artery invasion, two received initial treatment, with either preservation or reconstruction of the vertebral artery. The other six cases were tumor recurrences, treated by tumor and vertebral artery resection. Vertebral artery invasion was associated with carotid artery invasion in five patients and subclavian artery invasion in four.

Conclusions Carotid artery invasion by PTC did not extend beyond the adventitia of the artery in the majority of patients. Most patients with vertebral artery invasion required tumor excision with vertebral artery resection.

Introduction

Among several adverse prognostic factors of papillary thyroid carcinoma (PTC), extrathyroidal invasion has the greatest negative prognostic impact. The reported incidence rate of extrathyroidal invasion of PTC ranges from 6 to 13% [1–5]. Administration of tyrosine kinase inhibitors (TKIs) is a new line of therapy for radioactive iodine-

refractory and progressive metastases or locoregional recurrence and unresectable tumors [6, 7]. However, there has been little discussion regarding which types of locoregional recurrence are unresectable. Generally, locoregional tumors presenting with great vessel and/or multiple organ invasion have been deemed to be unresectable.

The surgical management of locally advanced thyroid carcinoma is performed using complete or shave tumor excision. Complete resection provides a lower recurrence rate and better survival prognosis than shave excision. However, shave excision provides good functional preservation, while still having a relatively low frequency of

✉ Sueyoshi Moritani
sueyoshi.moritani@gmail.com

¹ Center for Head and Neck Surgery, Kusatsu General Hospital, 1660 Yabase Cho, Kusatsu, Shiga 5258585, Japan

locoregional recurrence. Moreover, microscopic residual tumor after shave excision has not been associated with cancer relapse. Therefore, the conservative surgical approach of shave excision, in combination with adjuvant radiotherapy, has become the surgical treatment recommended for most cases of advanced thyroid carcinoma [8–12]. That being said, decision regarding the best surgical approach for patients with great vessel invasion is challenging with regard to balancing surgical resectability of the tumor with minimizing life-threatening complications and optimizing prognosis. Therefore, our aim in this study was to evaluate the efficacy of tumor excision among patients with PTC invasion of the carotid or vertebral artery, in terms of type of surgical resection selected, complications and 10-year survival prognosis.

Materials and methods

We conducted a retrospective review of patients with PTC who underwent surgical treatment at the Kyoto Medical Center and Kusatsu General Hospital, between 1981 and 2010, to identify cases of PTC invasion of the carotid or vertebral artery. The following variables were extracted from the medical charts for analysis: prognosis, rate of locoregional or distant recurrence and postoperative complications. The institutional review board approved our study. Patient confidentiality was maintained, and informed consent was obtained from all patients.

Cervical ultrasound examination was routinely performed for all patients with a thyroid carcinoma. For patients with suspected great vessel invasion, enhanced computed tomography (CT) or magnetic resonance imaging (MRI) was further performed for pre-operative evaluation. A balloon occlusion test was performed for patients with tumor encasement of $>180^\circ$ of the carotid artery, a large segmental obliteration of the fat between the carotid artery and the tumor or deformation of the carotid artery by the tumor. The extent of invasion of the carotid or vertebral artery evaluated by pre-operative imaging was confirmed by intra-operative findings. Arterial invasion was defined as tumor invasion of the arterial adventitia and lumen. The appropriate surgical technique for tumor excision in the presence of great vessel invasion was selected based on intra-operative findings and/or intra-operative pathological findings.

The treatment plan was implemented with curative surgical intent for all patients. Two types of resections were performed for great vessel invasion: subadventitial resection or en-block resection of the great vessel (arterial resection), with or without reconstruction of the artery. For patients in which tumor invasion did not exceed the arterial adventitia, complete resection of the tumor from the

subadventitial layer was performed, with preservation of the great vessel [13]. For patients with gross tumor invasion exceeding the arterial adventitia, tumor resection included the carotid or vertebral artery, with revascularization surgery performed, if possible, when the carotid artery was resected.

The following protocol was used for all patients with suspected great vessel invasion. First, we performed subadventitial resection for cases in which there was absence of circumferential encasement or luminal invasion. For cases in which invasion exceeded the arterial adventitia, we proceeded with arterial resection and reconstruction. All resections were performed using a No. 15 surgical blade under microscope guidance. During arterial resection and reconstruction of the great vessel, blood supply to the brain was preserved by an internal shunt.

Descriptive statistics were calculated for demographic and outcomes variables. As appropriate, between-group comparisons were performed (between the initial and recurrent treatment group), using a Mann–Whitney U test for continuous variables (age) and a Chi-squared test for categorical variables. Survival curves were constructed using the Kaplan–Meier method, with between-group comparisons performed using the log-rank test. A p value <0.05 was considered significant. All statistical analyses were conducted using the Ekuseru-Toukei 2015 software (SSRI Co. Ltd.).

Results

Over the study period, carotid invasion was identified in 49 of the 803 patients treated for PTC, with vertebral artery invasion identified in nine. All patients with carotid or vertebral artery invasion were referred to our hospital for surgical treatment. The follow-up duration after surgery was 7.4 ± 5.5 years, with none of the patients receiving radioactive iodine treatment for postoperative ablation of any residual invasive tumor cells of the great vessel.

The patient group with carotid artery invasion included 16 men (33%) and 33 women (67%). Among the 49 patients forming this group, invasion of the carotid artery was identified at the time of the initial diagnosis in 20. In the other 29 patients, invasion of the carotid artery was diagnosed as relapsing PTC. The median age of this patient group at the time of surgery was 68 years (range, 27–83 years). Among the 49 patients in the carotid invasion group, 14 (29%) underwent a balloon occlusion test for suspected massive carotid artery invasion, and 11 (22%) were diagnosed with lung metastasis prior to surgery (Table 1).

All 20 patients diagnosed with carotid artery invasion prior to initial treatment underwent subadventitial

Table 1 Baseline characteristics of patients with carotid artery invasion

		Initial treatment (<i>n</i> = 20)	Recurrent treatment (<i>n</i> = 29)	<i>p</i> value
Age, y	Mean (SD)	67.5 (13.8)	65.5 (9.3)	0.55
Sex	Male	6 (30%)	10 (34%)	0.98
	Female	14 (70%)	19 (66%)	
Presentation	Well	16 (80%)	20 (69%)	0.6
	Poorly	4 (20%)	9 (31%)	
Distant metastasis prior to great vessel invasion		3 (15%)	8 (28%)	0.49

SD, standard deviation; y, years; well, well differentiated; poorly, poorly differentiated

resection. By comparison, of the 29 patients diagnosed with carotid artery invasion at the time of PTC relapse, 27 underwent subadventitial resection and two underwent arterial resection with reconstruction of the carotid artery (Figs. 1, 2). Of the 20 patients receiving initial treatment, invasion was identified as being from the primary thyroid cancer in 11 cases and from lymph node metastasis in the other nine cases.

The 10-year disease-specific survival rate was shorter among relapsing patients than in patients who underwent initial treatment (21.7 vs 69.3%, respectively, $p = 0.59$; Fig. 3). Over the follow-up period, 14 patients died, nine due to a distant metastasis, one due to a locoregional recurrence, two due to a rupture of the carotid artery and

two of ‘other’ causes. As for the prognosis of the two patients who underwent carotid artery resection and reconstruction, one patient had lung and bone metastases and died 9 months after surgery, due to a rapid progress of distant metastases, while the other died 65 months after surgery because of lung metastases.

Overall in the carotid invasion group, there were 14 cases of locoregional recurrence and 15 cases of distant recurrence, with the rate of distant recurrence being greater in the recurrent than initial treatment group ($p = 0.032$, Chi-squared test, Table 2). Among the cases of locoregional recurrence, the lesion was located in the carotid artery in one patient (2%), which included invasion of the trachea and esophagus. The recurrent tumor in this case

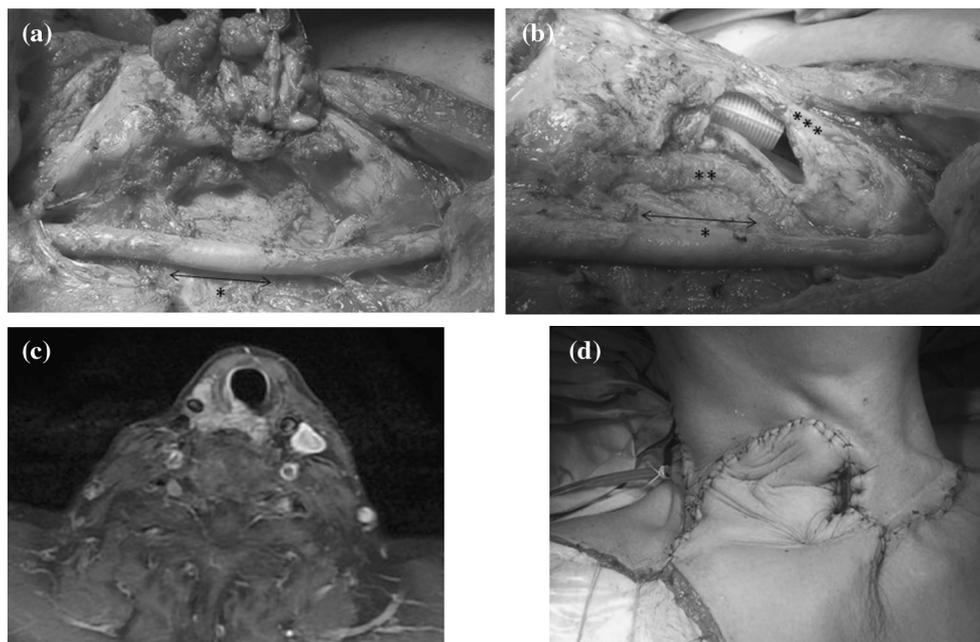


Fig. 1 Common carotid artery invasion from recurrent PTC (subadventitial resection case). Circumferential encasement of $>180^\circ$ of the right common carotid artery, with tracheo-esophageal invasion suspected on pre-operative MRI (c). Subadventitial resection and ligation of the intraluminal resected area of the common carotid artery (*), muscle layer resection of the esophagus (**), and window

resection of the trachea (***) were performed for PTC relapse (a, b). The right common carotid artery was covered using a deltopectoral flap and separated from the tracheo-cutaneous fistula (d). The tracheo-cutaneous fistula was closed in stages. MRI, magnetic resonance imaging; PTC, papillary thyroid carcinoma

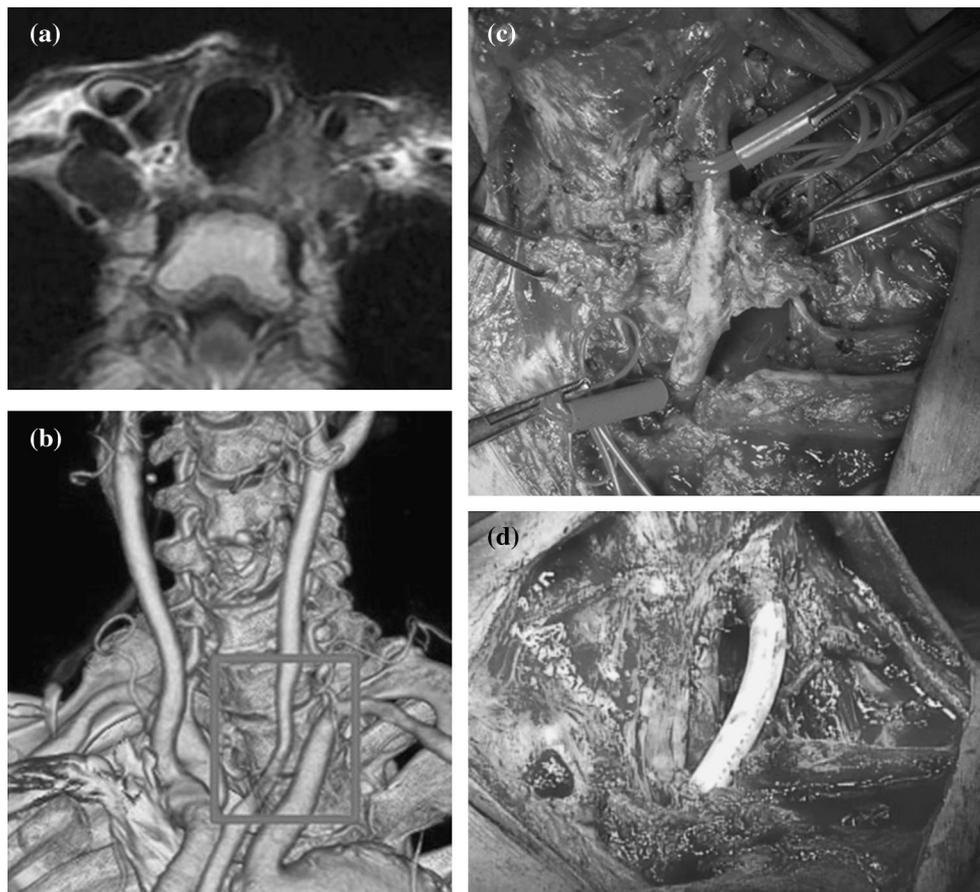


Fig. 2 Common carotid artery invasion from recurrent PTC (arterial resection and reconstruction case). Circumferential encasement of approximately 270° of the left common carotid artery, with tracheo-esophageal invasion suspected on pre-operative MRI (a). Carotid artery stenosis was delineated by CT angiography (b). Although subadventitial resection of the common carotid artery, from the

noninvasive area, was initiated, vessel invasion beyond the subadventitia was noted at the ventral side of the carotid artery (c). Common carotid artery resection and reconstruction, using an artificial vessel (8 mm), was performed (d). CT, computed tomography; MRI, magnetic resonance imaging; PTC, papillary thyroid carcinoma

was noted after subadventitial resection and was subsequently managed by subadventitial resection and total laryngo-pharyngo-cervical esophagotomy, followed with reconstruction of the pharyngo-esophagus, using a free jejunum flap, as a salvage surgery.

Rupture of the carotid artery was observed in three patients, being caused by infection after tracheal or esophagus resection in two patients and by injury to the innominate artery, following clavicular resection and mediastinal dissection, in the remaining patient. Of the three patients with carotid artery rupture, only one patient survived, being treated with innominate artery ligation, without neurological complications.

Forty-one of the 49 patients (84%) in the carotid artery invasion group were diagnosed with PTC invasion into other surrounding organs (Table 3). All patients receiving initial treatment had invasion of surrounding organs, including the recurrent laryngeal nerve (RLN; $n = 17$), trachea ($n = 11$), esophagus ($n = 11$), larynx ($n = 8$) and

great vessel ($n = 1$). In the recurrent treatment group, 21 of 29 patients had invasion of surrounding organs, including the trachea ($n = 14$), esophagus ($n = 14$), larynx ($n = 11$), RLN ($n = 8$) and great vessel ($n = 5$).

The nine patients with vertebral artery invasion included one man (11%) and eight women (89%). Among these nine cases, two were initial cases of PTC with vertebral artery invasion and seven were diagnosed with vertebral artery invasion during cancer relapse. The median age at the time of surgery in this group was 60 years (range, 51–78 years), with a follow-up period of 6.3 ± 3.2 years.

The two patients who received initial treatment underwent subadventitial resection or arterial resection with reconstruction of the vertebral artery. Among the seven patients diagnosed during PTC relapse, six (87%) who received recurrent treatment underwent arterial resection without reconstruction of the vertebral artery. Among the cases of locoregional recurrence, the lesion was located in the vertebral artery in one patient (11%). In this patient, the

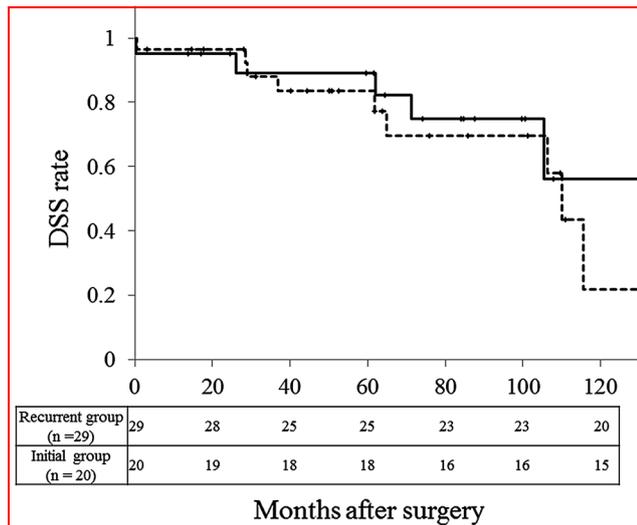


Fig. 3 Comparison of DSS rates between patients with carotid artery invasion receiving initial or recurrent treatment. The solid line represents patients who received initial treatment for carotid artery invasion ($n = 20$). The dotted line represents patients who received recurrent treatment for carotid artery invasion ($n = 29$). The 10-year DSS rate in the relapsing group was shorter than that in the initial treatment group (21.7 vs 69.3%, $p = 0.59$). DSS, disease-specific survival

recurrent tumor was noted after subadventitial resection and managed by arterial resection, as a salvage surgery. One patient had a cerebellar infarct as a postoperative complication of vertebral artery resection (Fig. 4).

All patients with vertebral artery invasion had PTC invasion of other surrounding organs, with an accompanying invasion of the carotid or subclavian artery invasion identified in five and four cases, respectively (Table 4).

Discussion

In our study, we demonstrated that most patients with carotid artery invasion by PTC can be managed with tumor resection of the subadventitial layer, which provided satisfactory locoregional control for patients with carotid artery invasion, with death in this patient group usually resulting from distant metastases. In contrast, most patients with vertebral artery invasion required combined tumor and vertebral artery resection.

Enhanced CT and MRI are effective modalities to detect great vessel invasion by malignant tumors prior to surgery, with segmental obliteration of the fat between the tumor and the artery, deformity of the artery and tumor encasement of the artery being radiological features used to predict great vessel invasion. Circumferential involvement of $>180^\circ$ of the artery on CT or 270° on MRI have been reported as being predictive of great vessel invasion [14–17]. Of note, some studies have reported that imaging is not reliable for detection of carotid artery invasion due to the high number of false-positive diagnoses. Diagnosis is further limited by difficulty in the histological assessment of carotid artery invasion, even at surgery, with tumor tissue often being indistinguishable from postoperative scar tissue.

Sharp dissection using a surgical blade under microscope guidance and maintenance of a blood-free operative field are effective in producing a sharper margin between normal structures and tumorous lesions, leading to easier detection of tumor invasion beyond the adventitia. In cases of tumor invasion beyond the adventitia, we have opted to proceed with arterial resection and reconstruction. To date, however, surgical treatment of carotid artery invasion has been reported only for head and neck squamous cell carcinoma (HNSCC), with a high rate of neurological complications and mortality having been reported after carotid artery resection and ligation. Although complication (15–20%) and mortality rates (16–20%) have been reduced with the use of carotid artery reconstruction, the frequency of postoperative complications of carotid artery resection remains high [18–21]. Subadventitial resection provides a potential method for surgical removal of the tumor, while maintaining cerebrovascular circulation, and should be considered for patients with carotid artery involvement of $<180^\circ$ on CT [15, 22]. However, histopathologic analysis of carotid artery specimens following this technique revealed microscopic disease within the arterial wall, which might lead to increased rates of recurrence and inferior oncologic outcomes. For these reasons, there is currently no consensus regarding the optimal surgical strategy for the treatment of carotid artery invasion. As well, it is important to consider prior research which has shown poor prognosis for patients with HNSCC infiltration

Table 2 Locoregional recurrence and distant recurrence in patients with common carotid artery invasion

	Initial treatment ($n = 20$)	Recurrent treatment ($n = 29$)	p value
Locoregional recurrence	3 (15%)	11 (38%)	0.056
Locoregional recurrence in the CCA	1 (5%)	0	
Distant recurrence	3 (15%)	12 (41%)	0.032

CCA, common carotid artery

Table 3 Carotid artery invasion accompanied by invasion of other structures

	Initial treatment (<i>n</i> = 20)	Recurrent treatment (<i>n</i> = 29)	<i>p</i> value
Trachea	11 (55%)	14 (48%)	0.64
Shaving excision	4	3	
Window resection	7	11	
Larynx	8 (40%)	11 (38%)	0.88
FW resection	7	5	
Partial/subtotal Lx		5	
Total Lx	1	1	
Esophagus	11 (55%)	14 (48%)	0.64
Muscle layer resection	10	10	
Reconstruction	1	4	
RLN	17 (85%)	8 (26%)	<0.01
Resection	2	6	
Reconstruction	15	2	
Great vessels	1 (5%)	5 (17%)	0.20
Innominate A	1		
Subclavicular A		4	
Vertebral A		5	

FW, frame work; RLN, recurrent laryngeal nerve; Lx, laryngectomy; A, artery

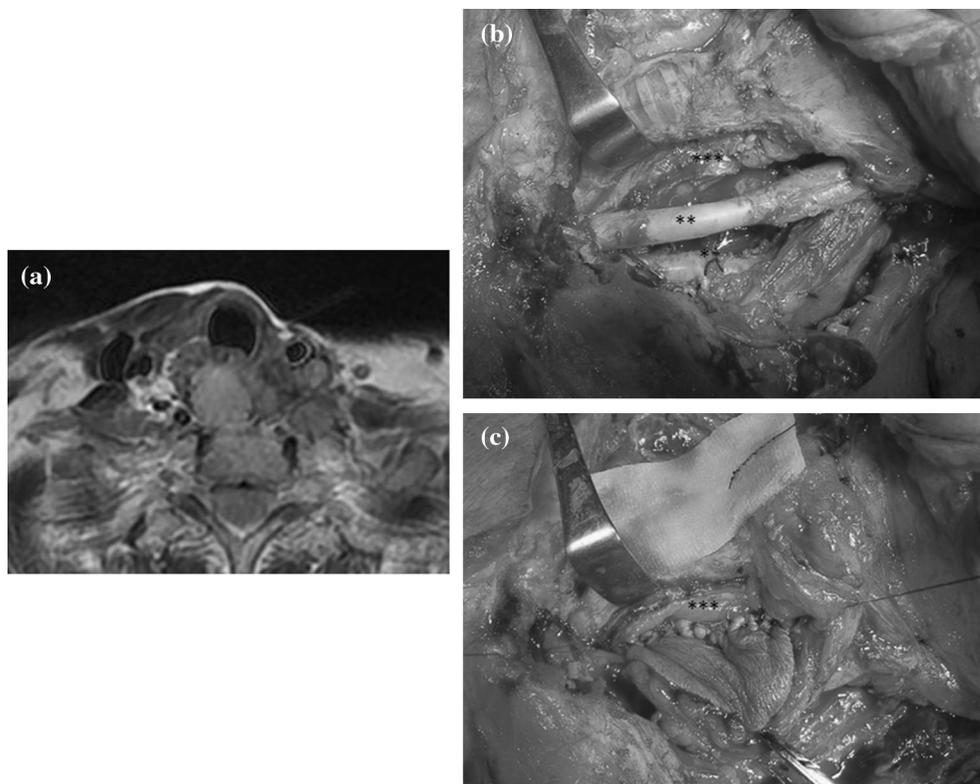


Fig. 4 Common carotid and vertebral artery invasion from recurrent PTC (subadventitial resection of carotid artery and resection of vertebral artery). One-third segmental obliteration of the fat between the tumor and the left common carotid artery, intraluminal esophageal invasion and left vertebral artery invasion (not delineated) was

suspected on MRI (a). Subadventitial resection of the carotid artery, resection of the left vertebral artery (without reconstruction), and intraluminal resection of the esophagus were performed (b). The esophagus was reconstructed using a free forearm flap (c). MRI, magnetic resonance imaging; PTC, papillary thyroid carcinoma

Table 4 Vertebral artery invasion accompanied by invasion of other structures

	I/R	Grade	Vertebral artery	CCA	SCA	Other organ invasion
Case 1	I	Well	Subadventitial resection			T, RLN
Case 2	I	Well	Reconstruction			V
Case 3	R	Well	Resection	Subadventitial resection	Subadventitial resection	T, L, E
Case 4	R	Well	Subadventitial resection	Subadventitial resection	Subadventitial resection	V
Case 5 ^a	R	Well	Resection	Subadventitial resection	Reconstruction	V, Lung
Case 6	R	Well	Resection	Subadventitial resection		T, L, E, V
Case 7	R	Poorly	Resection	Subadventitial resection	Resection	E, V
Case 8	R	Well	Resection			E, RLN
Case 9	R	Well	Resection			E, RLN

I, initial treatment; R, recurrent treatment; well, well differentiated; poorly, poorly differentiated; CCA, common carotid artery; SCA, subclavian artery; T, trachea; RLN, recurrent laryngeal nerve; Lx, laryngectomy; A, artery; V, vagal nerve; L, larynx; E, esophagus

^aPostoperative complication of cerebellar infarction caused by vertebral artery resection

into the carotid artery treated by complete resection [12, 18].

Our institution is a secondary referral center for the treatment of complicated cases of PTC with invasion of surrounding organs. Consequently, the rate of cases of PTC with great vessel invasion is high. We identified a 10-year disease-specific survival rate for patients with carotid artery invasion after surgery of 69.3% for the initial treatment group and 21.7% for recurrence treatment group. However, the survival rates of both groups were similar up to 8 years after surgery. This between-group difference in survival from 8 to 10 years was associated with an increased risk for distant metastasis in patients with recurrent metastatic disease. When considering only patients with invasion of the carotid artery in the initial treatment group, the locoregional recurrence was located in the carotid artery in only one patient (2%), indicative of the potential effectiveness of subadventitial resection in these cases. Differences in locoregional control between patients with PTC and HNSCC may be attributable to the biological differences between the two malignancies.

The rate of carotid artery invasion involving other surrounding structures exceeded 80%. Similarly, invasion of surrounding organs was identified in all patients with PTC invasion of the vertebral artery. In particular, secondary invasion of the carotid and subclavian artery was frequent in patients with vertebral artery invasion. The presence of multiple great vessel involvement poses an additional challenge to surgical decision-making, with vessel rupture and infection being common occurrences, especially in patients with laryngo-tracheal or esophageal intraluminal invasion. In our study group, carotid artery rupture occurred in three patients who had undergone subadventitial resection, with invasion to other organs, including intraluminal laryngo-tracheal or esophageal invasion. As infection is the primary cause of arterial rupture of

subadventitial rupture, meticulous coverage of the vascular structures of the resected artery, using coverage with a good supply, such as the deltopectoral flap or pectoralis major musculocutaneous flap, is important to provide a barrier against aerodigestive infections which might result in life-threatening postoperative complications.

Our study has several limitations which need acknowledgment. Foremost is the retrospective nature of our study design and the evaluation of a limited number of PTC cases with great vessel invasion, which are obvious potential sources of bias. Furthermore, we did not specifically evaluate the role of surgical resection compared to the use of TKIs or external beam radiotherapy, which have emerged as treatment for locoregional recurrent and unresectable tumors. This comparison would be important as the use of TKIs does carry the risk for great vessel rupture, caused by a drastic reduction in tumor size. Additionally, external beam radiotherapy has limited effectiveness against differentiated thyroid carcinoma and, therefore, complete cure by these treatments alone may not be feasible in locally advanced tumors.

In this study, we demonstrate that subadventitial resection achieved good locoregional control for patients with carotid artery invasion, with deaths usually caused by distant metastases. Treatment of vertebral artery invasion was more difficult, requiring more extensive resection due to the high prevalence of concurrent invasion of surrounding organs.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflicts to report.

References

1. McConehey WM, Hay ID, Woolner LB et al (1986) Papillary thyroid cancer treated at the Mayo Clinic, 1946 through 1970: initial manifestations, pathologic findings, therapy, and outcome. *Mayo Clin Proc* 61:978–996
2. Shah JP, Loree TR, Dharker D et al (1992) Prognostic factors in differentiated carcinoma of the thyroid gland. *Am J Surg* 164:658–661
3. Andersen PE, Kinsella J, Loree TR et al (1995) Differentiated carcinoma of the thyroid with extrathyroidal extension. *Am J Surg* 170:467–470
4. Hay ID, McConehey WM, Goellner JR (2002) Managing patients with papillary thyroid carcinoma: insights gained from the Mayo Clinic's experience of treating 2512 consecutive patients during 1940 through 2000. *Trans Am Clin Climatol Assoc* 113:241–260
5. Randolph GW, Kamani D (2006) The importance of preoperative laryngoscopy in patients undergoing thyroidectomy: voice, vocal cord function, and the preoperative detection of invasive thyroid malignancy. *Surgery* 139:357–362
6. Brose MS, Nutting CM, Jarzab B et al (2014) DECISION investigators 2014 Sorafenib in radioactive iodine-refractory, locally advanced or metastatic differentiated thyroid cancer: a randomised, double-blind, phase 3 trial. *Lancet* 384:319–328
7. Schlumberger M, Tahara M, Wirth LJ et al (2015) Lenvatinib versus placebo in radioiodine-refractory thyroid cancer. *N Engl J Med* 372:621–630
8. Meadows KM, Amdur RJ, Morris CG et al (2006) External beam radiotherapy for differentiated thyroid cancer. *Am J Otolaryngol* 27:24–28
9. Kebebew E, Clark OH (2003) Locally advanced differentiated thyroid cancer. *Surg Oncol* 12:91–99
10. Kim KH, Sung MW, Chang KH et al (2000) Therapeutic dilemmas in the management of thyroid cancer with laryngotracheal involvement. *Otolaryngol Head Neck Surg* 122:763–767
11. Samaan NA, Schultz PN, Hickey RC et al (1992) The results of various modalities of treatment of well differentiated thyroid carcinomas: a retrospective review of 1599 patients. *J Clin Endocrinol Metab* 75:714–720
12. Farahati J, Reiners C, Stuschke M et al (1996) Differentiated thyroid cancer. Impact of adjuvant external radiotherapy in patients with perithyroidal tumor infiltration (stage pT4). *Cancer* 77:172–180
13. Manzoor NF, Russell JO, Bricker A et al (2013) Impact of surgical resection on survival in patients with advanced head and neck cancer involving the carotid artery. *JAMA Otolaryngol Head Neck Surg* 39:1219–1225
14. Yu Q, Wang P, Shi H et al (2003) Carotid artery and jugular vein invasion of oral-maxillofacial and neck malignant tumors: diagnostic value of computed tomography. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 96:368–372
15. Yoo GH, Hocwald E, Korkmaz H et al (2000) Assessment of carotid artery invasion in patients with head and neck cancer. *Laryngoscope* 110:386–390
16. Yousem DM, Hatabu H, Hurst RW et al (1995) Carotid artery invasion by head and neck masses: prediction with MR imaging. *Radiology* 195:715–720
17. Rapoport A, Tornin Ode S, Beserra Júnior IM et al (2008) Assessment of carotid artery invasion by lymph node metastasis from squamous cell carcinoma of aero-digestive tract. *Braz J Otorhinolaryngol* 74:79–84
18. Snyderman CH, D'Amico F (1992) Outcome of carotid artery resection for neoplastic disease: a meta-analysis. *Am J Otolaryngol* 13:373–380
19. Wright JG, Nicholson R, Schuller DE et al (1996) Resection of the internal carotid artery and replacement with greater saphenous vein: a safe procedure for en bloc cancer resections with carotid involvement. *J Vasc Surg* 23:775–780
20. Lore JMJ, Boulos EJ (1981) Resection and reconstruction of the carotid artery in metastatic squamous cell carcinoma. *Am J Surg* 142:437–442
21. Konno A, Togawa K, Iizuka K (1981) Analysis of factors affecting complications of carotid ligation. *Ann Otol Rhinol Laryngol* 90:222–226
22. Ozer E, Agrawal A, Ozer HG et al (2008) The impact of surgery in the management of the head and neck carcinoma involving the carotid artery. *Laryngoscope* 118:1771–1774