Diagnostic potential of ultrasonography and computed tomography in differentiating cervical lymph node metastasis of thyroid cancer: a systematic review and meta-analysis

Yong-Hui Chen, Ying-Qiang Zhang

Department of Nuclear Medicine, Peking Union Medical College Hospital, Chinese Academy of Medical Sciences and Peking Union Medical College, China

Submitted: 16 July 2019
Accepted: 25 October 2019

Arch Med Sci
DOI: https://doi.org/10.5114/aoms.2020.95104

Corresponding author:
Yong-Hui Chen MD
Department of Nuclear Medicine
Peking Union Medical College Hospital
Chinese Academy of Medical Sciences and Peking Union Medical College
No. 1 Shuaifuyuan
Dongcheng District
Beijing, 100730, China
E-mail: chenyufirst@sina.com

Abstract

Introduction: Ultrasonography (US) and computed tomography (CT) are the most common diagnostic modalities of cervical lymph node metastasis of thyroid cancer, but few studies have been conducted to compare their diagnostic accuracy, with inconclusive results.
Material and methods: Multiple databases including PubMed, Springer, EMBASE, Ovid, and the Cochrane Library were searched with the keywords "thyroid cancer OR thyroid carcinomas", "cervical lymph nodes", "metastatic OR metastasis", and "ultrasonography OR ultrasound OR CT OR computed tomography" in June 2018. Full-text articles comparing diagnostic accuracy of US and CT were reviewed. Meta-analyses were conducted to estimate sensitivity and specificity. The forest plots of sensitivity and specificity and summary receiver operating characteristic curves (SROC) are also presented in this article.
Results: Finally, 8 of 1785 studies which eventually met the inclusion criteria were selected in this study. The mean sensitivities and specificities of CT in whole and central cervical areas were 0.65, 0.56 and 0.89, 0.83, respectively, while for US, the sensitivities and specificities were 0.58, 0.39 and 0.89, 0.91, respectively. The area under the curve (AUCs) observed of CT and US in whole, central and lateral cervical areas were 0.79 vs. 0.79, and 0.76 vs. 0.67. Because only a few articles were included in this study, publication bias was not assessed.
Conclusions: The diagnostic accuracy of US and CT was comparable. The specificity of these two methods was much higher than the sensitivity.

Key words: thyroid cancer, cervical, metastasis, diagnosis.

Introduction

For patients with papillary thyroid cancer (PTC), cervical lymph node metastasis (LNM) is one of the most important prognostic factors and occurs in nearly 30–90% of cervical lymph nodes located around the thyroid gland in the neck [1–3]. Despite the fact that LNM does not increase the overall risk of mortality of PTC patients, it actually affects the possibility of local tumor recurrence [4–6]. The high rates of recurrence of PTC suggest that many patients have cervical lymph node metastasis before initial surgery. Moreover, if these metastases could be detected and removed promptly, both recurrence and morbidity could be reduced [7]. LNM could affect surgical treatment and patient management. It is vital that clinicians evaluate cervical LNM adequately and make treatment decisions regarding indications and extent of surgery, which are the most contested issues in clinical management. Clinically, apparent cervical LNM may be preoperatively detected by palpation or imaging studies, including ultrasonography (US), computed tomography (CT), magnetic resonance imaging (MRI), and positron emission tomography (PET) [8, 9].

In the past, detection of cervical lymph node metastasis was based primarily on palpation, which may not be accurate. The enlarged cervical lymph nodes may not be palpated when they are small or located behind the sternocleidomastoid muscles, carotid artery or jugular vein. Detection by imaging of LNM is much more accurate than by clinical palpation. US is one of the most common and widely used primary imaging modalities for preoperative evaluation of differentiated thyroid cancer [10]. US can be used to guide aspiration of thyroid nodules and detect suspicious lymph nodes, and sometimes it has been regarded as the gold standard and preferred method for thyroid cancer. The American Thyroid Association guidelines recommend preoperative US for lymph nodes in patients undergoing thyroidectomy after needle aspiration biopsies demonstrate malignancy [11]. It is a simple, fast and sensitive method, and high-resolution ultrasound can detect lymph nodes as small as 5 mm, and therefore can determine the extent of surgery [12–15]. US is a commonly recommended imaging method for evaluating LNM in patients with PTC [11], but it has some limitations, including operator dependency, subjectivity, and superficial examination areas. Compared with US, CT has proved to be an accurate modality in detecting LNM of head and neck squamous cancer [16, 17]. CT may play a role in depicting lymph nodes in occult areas and evaluating tumor extension to adjacent structures, which is limited in US. It could overcome the drawbacks of US, and show the location, extent and invasion of adjacent structures, which could be used to assess metastatic probability [18].

Though several studies have explored the features and diagnostic values of US and CT of LNM in PTC patients [19–21], only a few studies have been conducted to compare these methods for detecting cervical LNM, and their comparison results of diagnostic accuracy were different. The aim of the present study was to compare the diagnostic accuracy between US and CT in the initial evaluation of cervical LNM for patients with thyroid cancer.

Material and methods

Search strategy

Studies on the diagnostic accuracy of US and CT were searched comprehensively in databases including PubMed, Springer, EMBASE, Ovid, and the Cochrane Library from inception to June 2018. The systematic review and meta-analysis was undertaken with no language restriction, and the following keywords were used in the independent and efficient searching process: 1) thyroid cancer OR thyroid carcinomas; 2) cervical lymph nodes; 3) metastatic OR metastasis; 4) ultrasonography OR ultrasound OR CT OR computed tomography. The terms were assembled with the connection symbol “AND” in searching, and to obtain the missing relevant studies, the reference lists of identified articles were also reviewed.

Citation selection

The titles and abstracts of the identified articles were screened independently by two of our members (Chen YH and Zhang YQ). Then, full texts of the studies likely to be relevant were obtained.

The studies had to meet the following inclusion criteria: 1) A diagnostic study; 2) Comparison of the accuracy of ultrasonography and CT; 3) Patients with thyroid cancer; 4) Full text available on the university network; 5) All cited studies had informed consent from each study participant and protocol approval by an ethics committee or institutional review board.

Exclusion criteria: 1) Studies on other disease; 2) Studies with incomplete outcome data (without original or comparable data); 3) No full text.

The included articles were determined by two investigators together, who checked whether the study met the above-mentioned conditions. All disagreements were resolved through discussion to reach a consensus.

Data extraction

The two reviewers reviewed the full texts of the articles independently and extracted the detailed data. In this study, the characteristics extracted included the name of the first author, year of publication, year of onset, time range of diagnosis, sex distribution, age range of patients, sample size and detection site. In this study, the extracted parameters mainly included the true positive (TP), true negative (TN), false positive (FP), and false negative (FN), and the clinical utility indices (CUI) were calculated ($CUI+ = TP*TP/(TP + FN)*(TP + FP)$, $CUI- = TN*TN/(TN + FP)*(TN + FN)$). The data extracted were determined by investigators together and if any dispute occurred, a third investigator was asked to solve it.

Risk of bias

We performed bias analysis to assess the quality of included articles, and the table of risk was presented with the criteria of QUADAS-2.

Statistical analysis

The meta-analyses were performed with STATA 10.0 software. As a diagnostic test, the overall sensitivity and specificity of US and CT, as well as their corresponding 95% confidence intervals (CIs), were calculated on the basis of TP, TN, FP and FN. The forest plots of the sensitivity and specificity and the summary receiver operating characteristic curves (SROC) were also generated. In our study, a *p*-value < 0.05 was considered as statistically significant.

Results

Search results

In total 1785 related studies (660 in PubMed, 350 in Springer, 273 in EMBASE, 393 in Ovid, and 109 in the Cochrane Library; 1743 in English, 21 in Chinese, 12 in Korean, 6 in German and 3 in French) were initially identified from the databases and reviewed in depth. Finally, 8 articles (7 in English and 1 in Chinese) [22–30] met all the inclusion criteria. The remaining 1777 articles were excluded due to duplication (416), irrelevant studies (574), incomplete outcome data (488), reviews (293), or lack of the full text (6). Figure 1 shows the flow diagram of the study search process and the reasons for exclusion. Eight studies were included in the whole detection site of cervical lymph nodes, and 5 of them studied the central site and 4 studied the lateral site.

Characteristics of included studies

Detailed data of the included articles are shown in Table I. In total, 8917 patients with thyroid cancer were included in these studies, and the nodes in the LNM group and the no-LNM groups were 4776 and 4141, respectively. Table II shows the TP, TN, FP, FN and CUI of each article.

Quality assessment

The risk of bias table for evaluating each study is shown in Table III.

Results of meta-analysis

Comparison of the whole cervical area

The forest plots for the combined sensitivity and specificity of CT and US in the whole cervical area are shown in Figures 2 and 3, respectively. The figures show that the sensitivity and specificity of CT were 0.65 (95% CI: 0.54–0.75) and 0.89 (95% CI: 0.73–0.96), and those of US were 0.58 (95% CI: 0.46–0.69) and 0.89 (95% CI: 0.79–0.95). Both the sensitivities and specificities of these two methods were comparable ($p > 0.05$). The SROC that evaluated these two promising technologies for diagnosing cervical lymph nodes from thyroid cancer are presented in Figures 4 and 5, respectively. As shown in the figures, the area under the SROC curve (AUC) was 0.79 (95% CI: 0.75–0.83) for CT, and 0.79 (95% CI: 0.75–0.82) for US. No statistically significant difference in AUC was observed between these two methods ($p > 0.05$).

Comparison of the central cervical area

Four of the 8 included studies examined the central cervical area. The results are presented in Figures 6 and 7. The sensitivity and specificity of CT were 0.56 (95% CI: 0.38–0.72) and 0.83 (95% CI: 0.68–0.91), respectively, and those of US were 0.39 (95% CI: 0.25–0.54) and 0.91 (95% CI: 0.77–0.97), respectively. There was no significant difference between these two methods. Figures 8 and 9 show that the SROC and the AUCs of CT and US were 0.76 (95% CI: 0.72–0.80) and 0.67 (95% CI: 0.63–0.71), respectively. The AUC of CT was much larger than that of US.

Discussion

According to the results above, both CT and US could be useful methods to diagnose LNM in the clinic, especially in specificity. Similarly to previous

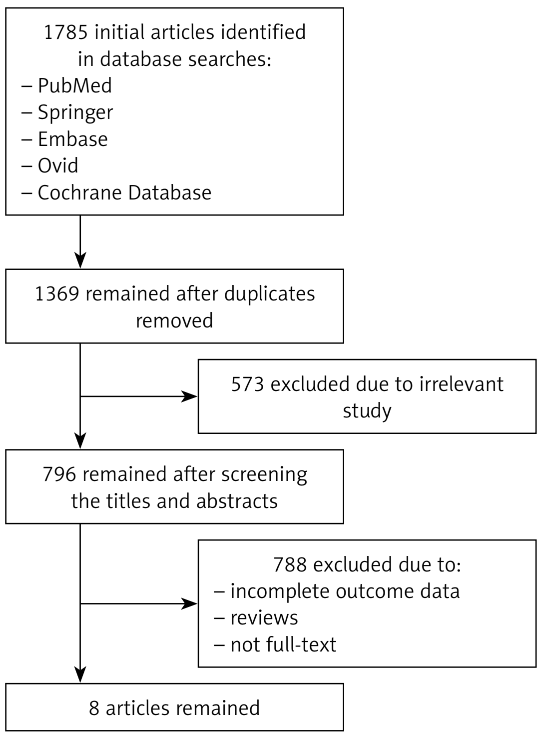

Figure 1. Flow diagram of study search process and reasons for exclusion

Table I. Details of the articles included in this study

Study	Year	Year of onset	Age range	Sex distribution (male/female)	Sample size (LNM/no LNM)	Experimental design	Gold standard	Detection site
Ahn	2008	January 2005 to December 2005	20 to 68	7/30	117/66	Prospective cohort study	US	Whole, central, lateral
Choi JS	2009	February 2006 to April 2007	20 to 74	44/255	160/192	Prospective cohort study	US	Whole, central, lateral
Choi YJ	2010	January 2007 to December 2008	16 to 83	121/468	238/351	Prospective cohort study	US	Whole
Kim	2016	January 1997 to June 2015	–	–	3826/2751	Prospective cohort study	US	Central
Lee	2013	January 2007 to May 2010	15 to 82	45/207	187/371	Prospective cohort study	US	Whole, central, lateral
Li	2018	March 2016 to March 2016	19 to 73	43/103	122/24	Prospective cohort study	US	Whole
Seo	2012	August 2008 to August 2011	25 to 72	4/16	52/58	Prospective cohort study	US	Whole
Yoon	2009	February 2006 to September 2007	24 to 85	58/9	74/328	Prospective cohort study	US	Whole

studies [26, 31], our results showed that relatively low sensitivity and high specificity of both US and CT in preoperative detection of LNM from patients with PTC were observed (Figures 2, 3, 6, and 7). Theoretically, CT scans may have higher sensitivity for detecting LNM location. The results of our meta-analyses indicated that compared with US, CT had even comparable sensitivity and specificity in the whole and central site. However, according to Figures 4, 5, 8, and 9, the areas under the SROC curve in the whole site between US and CT shows no significant difference. But in the central cervical area, the AUC of CT was much larger than that of US, which means that CT is superior for central lymph node metastasis.

After the pathologic examination of the specimen, central compartment neck dissection combined with total thyroidectomy is recommended [32]. But the use of central dissection is controversial when LNM is clinically negative, as the necessity is still not standardized clinically [33, 34]. In our study, we did not conduct a comparison of the lateral cervical area due to the limited number of included articles. However, all the previous studies [23, 27, 28] have shown that the sensitivities of both CT and US in detecting the lateral cervical area were higher than the sensitivities in detecting the central cervical area, while the difference of specificity of these two methods in detecting lateral and central cervical areas was not statistically significant. There are two possible explanations for this. Most tumors in the head and neck metastasized to lateral lymph nodes, and studies have mainly focused on lymph node metastasis in the lateral area [35, 36]. The diagnostic criteria for lateral lymph nodes may be not applicable for the central compartment. Besides, the anatomical complexity of the thoracic inlet and the difficulty in reading the imaging results may also limit the application of imaging methods in the central compartment.

Based solely on our statistical results, we recommend CT as the detection method due to its larger AUC than US. However, the cost of CT in examining the thyroid gland is much higher than that of US. The patients and radiologist could choose the appropriate detection methods considering the cost-benefit principle. In view of the low sensitivity of both CT and US in the central cervical area, more diagnostic studies should be conducted to assess the accuracy of CT and US in the central compartment, or new methods should be found and used to diagnose the central LNM.

There are some potential limitations in this study. First of all, high observer bias may exist for the non-blind surgical approaches, and the perception of both surgeons and patients could influence the diagnostic results. Second, publication bias in our study was not assessed, due to the fact

Table II. True positive (TP), true negative (TN), false positive (FP), false negative (FN), clinical utility indices (CUI)+ and CUI– of each study

Study	Site	CT						US					
		TP	FP	FN	TN	CUI+	CUI–	TP	FP	FN	TN	CUI+	CUI–
Ahn	Whole	90	20	27	46	0.63 Satisfactory	0.44 Poor	73	14	44	52	0.52 Satisfactory	0.43 Poor
	Central	23	9	9	7	0.52 Satisfactory	0.19 Poor	17	5	14	11	0.42 Poor	0.3 Poor
	Lateral	67	11	19	39	0.67 Good	0.52 Satisfactory	56	9	30	41	0.56 Satisfactory	0.47 Poor
Choi JS	Whole	114	39	46	153	0.53 Satisfactory	0.61 Satisfactory	105	41	55	151	0.47 Poor	0.58 Satisfactory
	Central	74	39	37	149	0.44 Poor	0.63 Satisfactory	59	38	52	150	0.32 Poor	0.59 Satisfactory
	Lateral	40	0	9	4	0.82 Excellent	0.31 Poor	46	3	3	1	0.88 Excellent	0.06 Poor
Choi YJ	Whole	82	22	156	329	0.27 Poor	0.64 Good	75	27	163	324	0.23 Poor	0.61 Satisfactory
Kim	Central	1488	245	2338	2506	0.33 Poor	0.47 Poor	1052	113	2774	2638	0.25 Poor	0.47 Satisfactory
Lee	Whole	107	57	80	314	0.37 Poor	0.67 Good	78	21	109	350	0.33 Poor	0.72 Good
	Central	46	30	67	267	0.25 Poor	0.72 Good	26	9	87	288	0.17 Poor	0.74 Good
	Lateral	61	27	13	47	0.57 Satisfactory	0.5 Satisfactory	52	12	22	62	0.57 Satisfactory	0.62 Satisfactory
Li	Whole	86	11	36	13	0.62 Satisfactory	0.14 Poor	67	9	55	15	0.48 Poor	0.13 Poor
Seo	Whole	33	3	19	55	0.58 Satisfactory	0.7 Good	36	6	16	52	0.59 Satisfactory	0.69 Good
Yoon	Whole	57	2	17	326	0.74 Good	0.94 Excellent	58	5	16	323	0.72 Good	0.94 Excellent

Table III. Risk of bias table for this meta-analysis

	Ahn	Choi JS	Choi YJ	Kim	Lee	Li	Seo	Yoon
Was a consecutive or random sample of patients enrolled?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Was a case-control design avoided?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Did the study avoid inappropriate exclusions?	Yes	Yes	Unclear	Yes	Unclear	Yes	Yes	Yes
Could the selection of patients have introduced bias?	Low	Low	Low	Low	Low	Low	Low	Low
Are there concerns that the included patients do not match the review question?	Low	Low	Low	Low	Low	unclear	Low	Low
Were the index test results interpreted without knowledge of the results of the reference standard?	No	No	No	No	No	No	No	No
If a threshold was used, was it pre-specified?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Could the conduct or interpretation of the index test have introduced bias?	Low	Low	High	Unclear	Low	Low	Low	Low
Are there concerns that the index test, its conduct, or interpretation differ from the review question?	Low	Low	Low	Low	Low	Low	Low	Low
Is the reference standard likely to correctly classify the target condition?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Were the reference standard results interpreted without knowledge of the results of the index test?	No	No	No	No	No	Unclear	No	No
Could the reference standard, its conduct, or its interpretation have introduced bias?	Low	Low	High	Low	Low	Low	Unclear	Low
Are there concerns that the target condition as defined by the reference standard does not match the review question?	Low	Low	Low	Unclear	Low	Low	Low	Low
Was there an appropriate interval between index test(s) and reference standard?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Did all patients receive a reference standard?	Yes	Yes	Yes	Yes	Unclear	Yes	Yes	Yes
Did all patients receive the same reference standard?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Were all patients included in the analysis?	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes
Could the patient flow have introduced bias?	Low	Low	Low	Low	Low	Low	Low	Low

that few articles were included, and the limited numbers of patients as well as articles included in our study would affect the quality and the results of the study (Table III). Also, because of the lack of stage information of thyroid carcinoma, the accuracy of the US and CT could be affected. Furthermore, in our study, there may be some information bias, resulting from devices changes in the wide time range of onset in included studies, and images changes of the different or blinded radiologist. In clinical practice, regular instrument maintenance and calibration, standardized training of radiologists and unified standard of diagnosis are necessary to reduce the information error.

In conclusion, the results of our meta-analysis demonstrated comparable diagnostic accuracy of US and CT. The specificity of both these methods was much higher than the sensitivity. More sen-

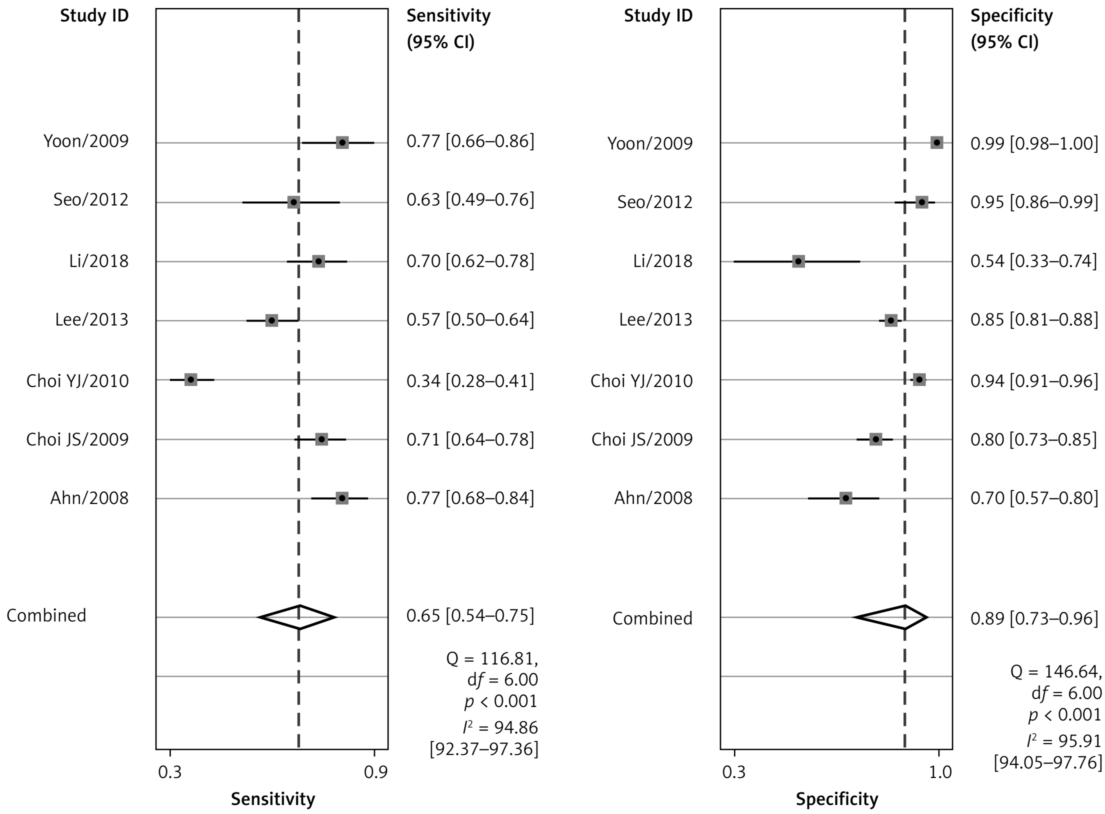

Figure 2. Forest plot for the combined sensitivity and specificity of CT in the whole cervical area

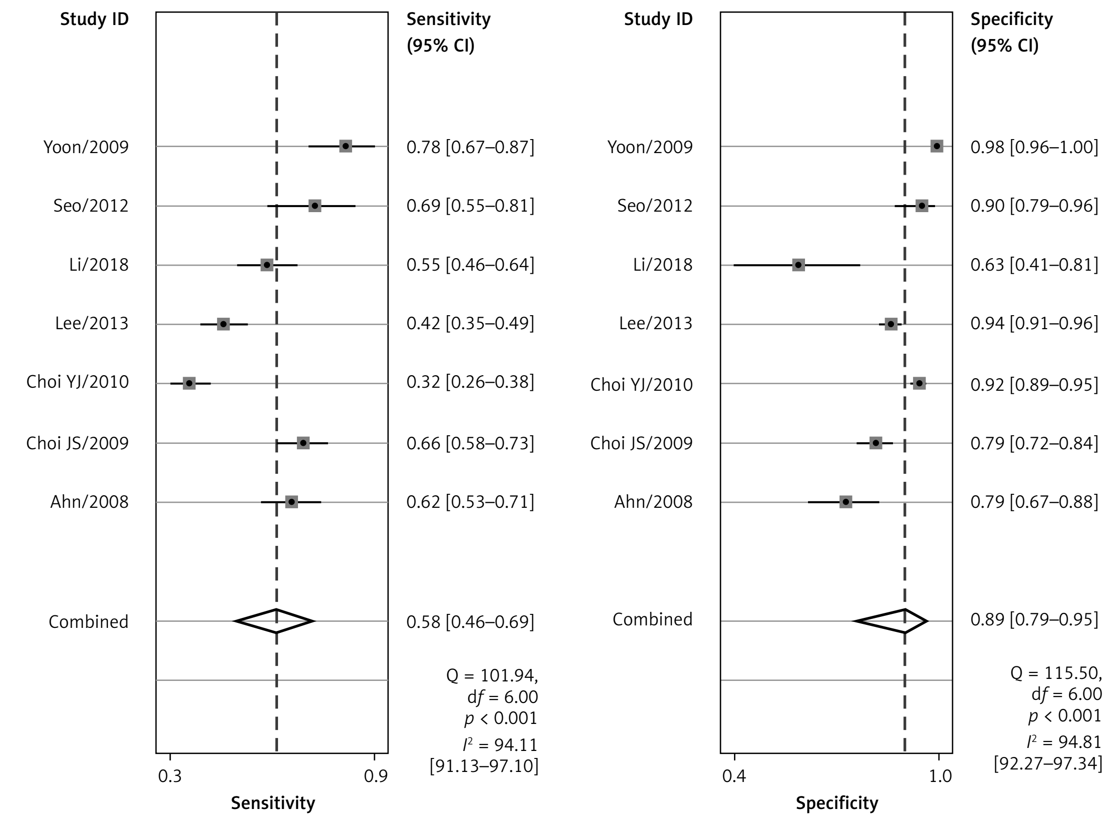

Figure 3. Forest plot for the combined sensitivity and specificity of US in the whole cervical area

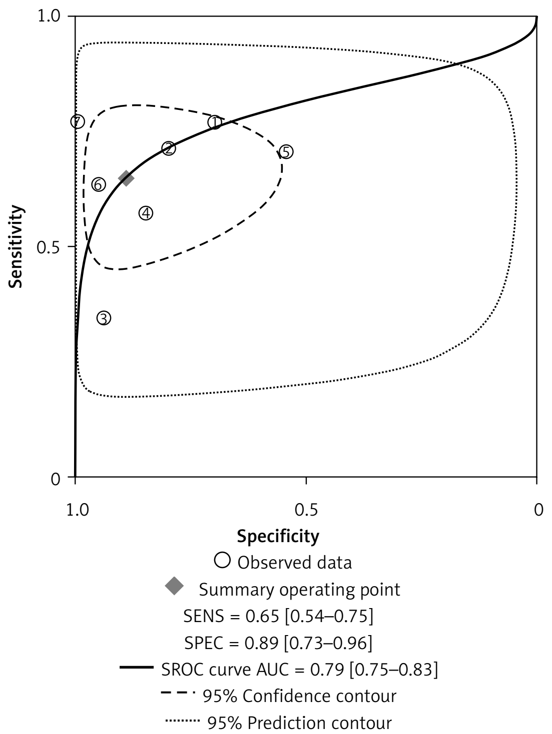

Figure 4. Summary receiver operating characteristic curves (SROC) of CT in the whole cervical area

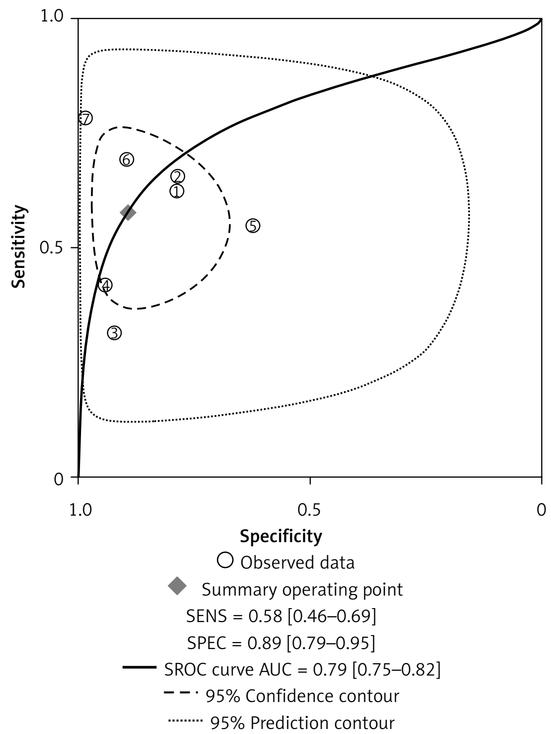

Figure 5. Summary receiver operating characteristic curves (SROC) of US in the whole cervical area

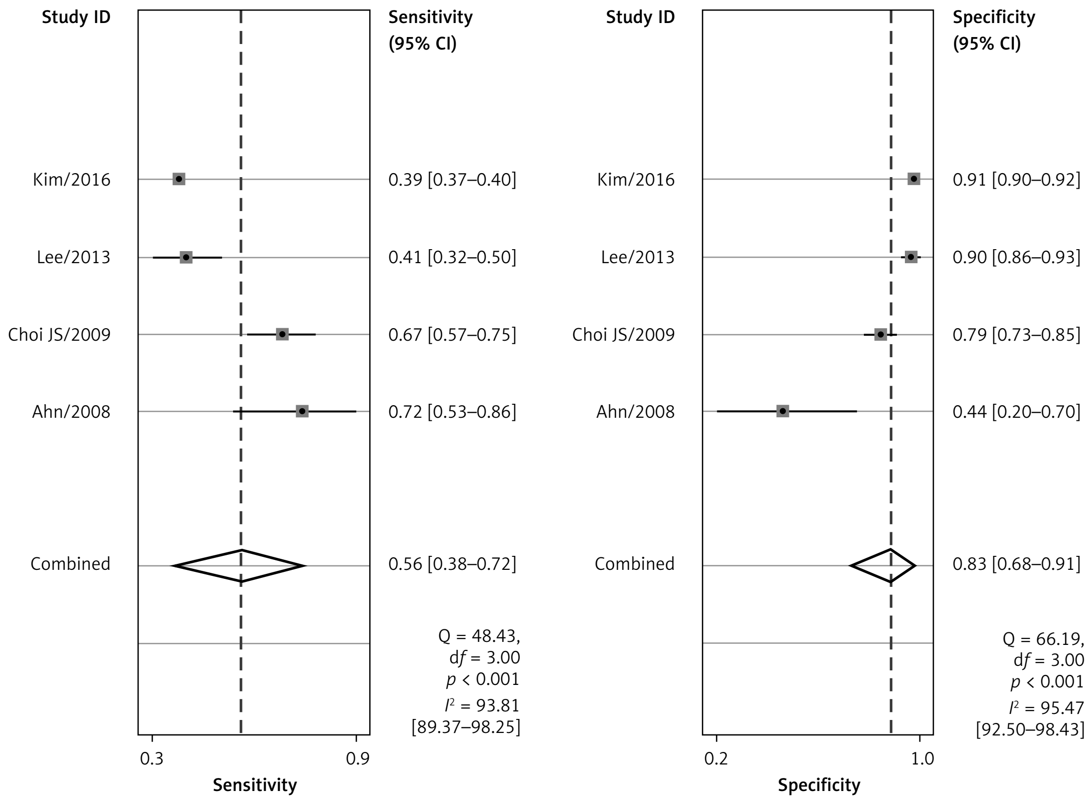

Figure 6. Forest plot for the combined sensitivity and specificity of CT in the central cervical area

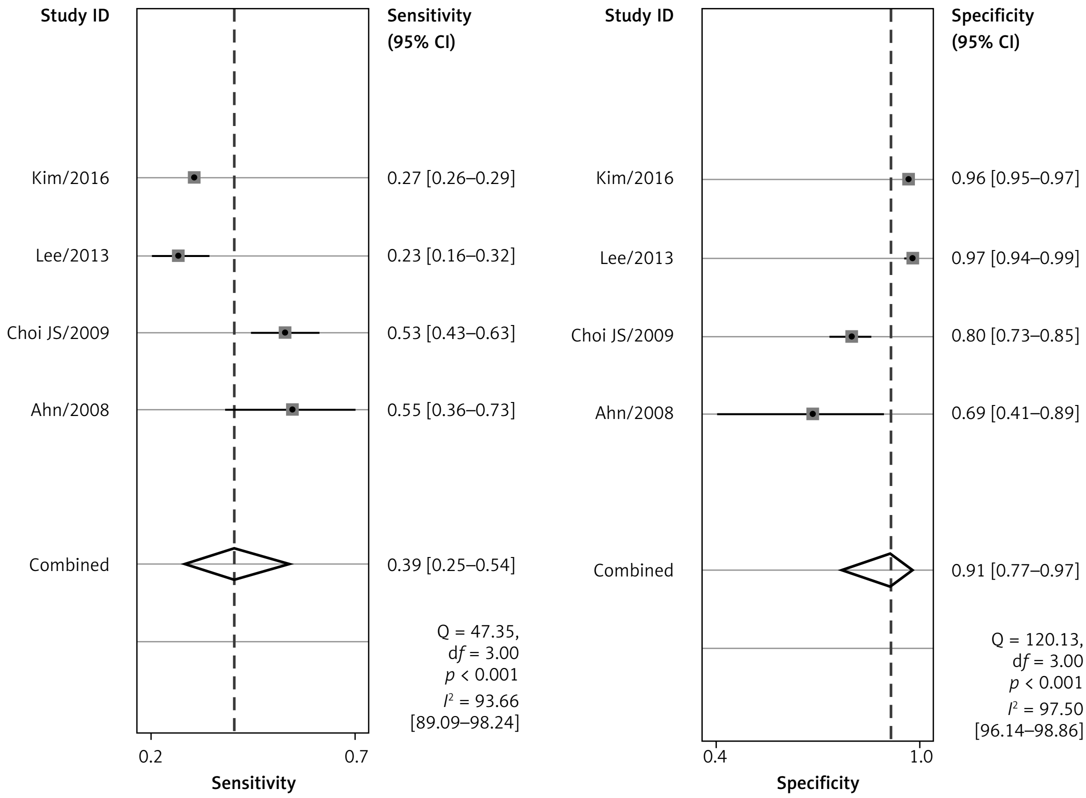

Figure 7. Forest plot for the combined sensitivity and specificity of US in the central cervical area

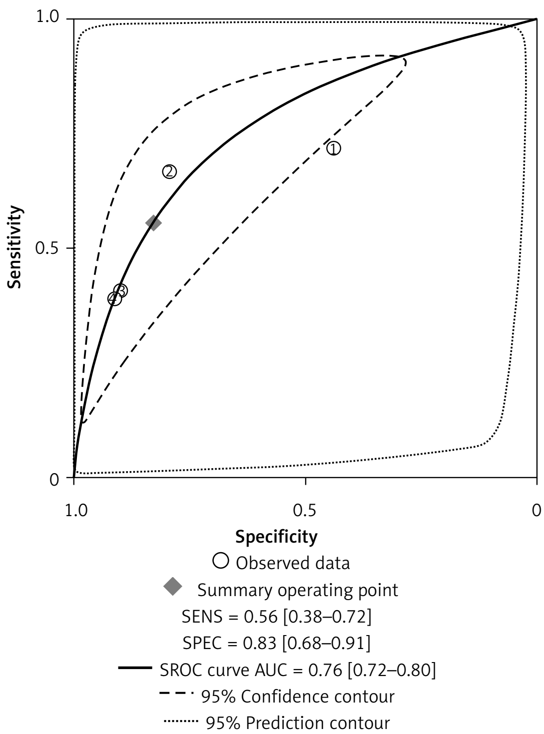

Figure 8. Summary receiver operating characteristic curves (SROC) of CT in central cervical area

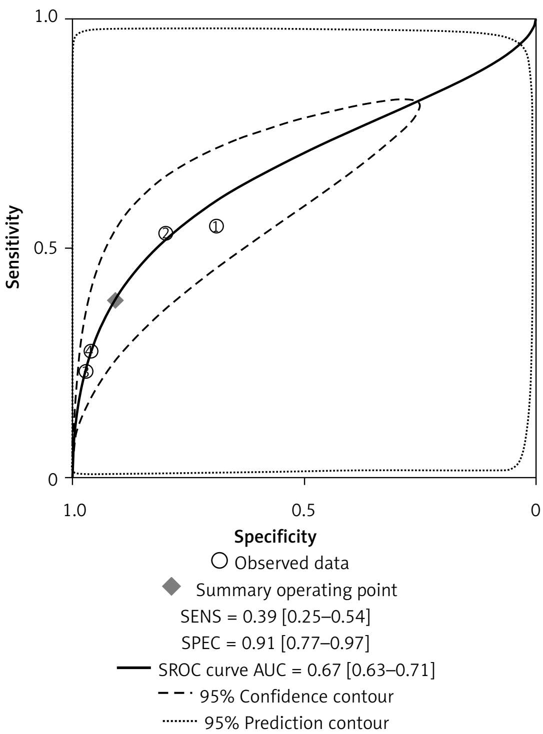

Figure 9. Summary receiver operating characteristic curves (SROC) of US in the central cervical area

sitive methods are required to detect LNM in the central neck.

Conflict of interest

The authors declare no conflict of interest.

References

1. Caron NR, Clark OH. Papillary thyroid cancer: surgical management of lymph node metastases. Curr Treat Options Oncol 2005; 6: 311-22.
2. Roh JL, Kim JM, Park CI. Lateral cervical lymph node metastases from papillary thyroid carcinoma: pattern of nodal metastases and optimal strategy for neck dissection. Ann Surg Oncol 2008; 15: 1177-82.
3. Kupferman ME, Patterson M, Mandel SJ, LiVolsi V, Weber RS. Patterns of lateral neck metastasis in papillary thyroid carcinoma. Arch Otolaryngol Head Neck Surg 2004; 130: 857-60.
4. McHenry CR, Rosen IB, Walfish PG. Prospective management of nodal metastases in differentiated thyroid cancer. Am J Surg 1991; 162: 353-6.
5. Mazzaferri EL, Jhiang SM. Long-term impact of initial surgical and medical therapy on papillary and follicular thyroid cancer. Am J Med 1994; 97: 418-28.
6. Shah JP, Loree TR, Dharker D, Strong EW, Begg C, Vlamis V. Prognostic factors in differentiated carcinoma of the thyroid gland. Am J Surg 1992; 164: 658-61.
7. Esnaola NF, Cantor SB, Sherman SI, Lee JE, Evans DB. Optimal treatment strategy in patients with papillary thyroid cancer: a decision analysis. Surgery 2001; 130: 921-30.
8. Cobin RH, Gharib H, Bergman DA, et al. AACE/AAES medical/surgical guidelines for clinical practice: management of thyroid carcinoma. American Association of Clinical Endocrinologists. American College of Endocrinology. Endocr Pract 2001; 7: 202-20.
9. Ito Y, Miyauchi A. Lateral and mediastinal lymph node dissection in differentiated thyroid carcinoma: indications, benefits, and risks. World J Surg 2007; 31: 905-15.
10. Watkinson JC, Franklyn JA, Olliff JF. Detection and surgical treatment of cervical lymph nodes in differentiated thyroid cancer. Thyroid 2006; 16: 187-94.
11. American Thyroid Association Guidelines Taskforce on Thyroid Nodules and Differentiated Thyroid Cancer; Cooper DS, Doherty GM, Haugen BR, et al. Revised American Thyroid Association management guidelines for patients with thyroid nodules and differentiated thyroid cancer. Thyroid 2009; 19: 1167-214.
12. Antonelli A, Miccoli P, Ferdeghini M, et al. Role of neck ultrasonography in the follow-up of patients operated on for thyroid cancer. Thyroid 1995; 5: 25-8.
13. Ito Y, Tomoda C, Uruno T, et al. Preoperative ultrasonographic examination for lymph node metastasis: usefulness when designing lymph node dissection for papillary microcarcinoma of the thyroid. World J Surg 2004; 28: 498-501.
14. Gonzalez HE, Cruz F, O'Brien A, et al. Impact of preoperative ultrasonographic staging of the neck in papillary thyroid carcinoma. Arch Otolaryngol Head Neck Surg 2007; 133: 1258-62.
15. Kouvaraki MA, Shapiro SE, Fornage BD, et al. Role of preoperative ultrasonography in the surgical management of patients with thyroid cancer. Surgery 2003; 134: 946-54; discussion 954-5.
16. Sarvanan K, Bapuraj JR, Sharma SC, Radotra BC, Khandelwal N, Suri S. Computed tomography and ultrasonographic evaluation of metastatic cervical lymph nodes with surgicoclinicopathologic correlation. J Laryngol Otol 2002; 116: 194-9.
17. King AD, Tse GM, Ahuja AT, et al. Necrosis in metastatic neck nodes: diagnostic accuracy of CT, MR imaging, and US. Radiology 2004; 230: 720-6.
18. van den Brekel MW. Lymph node metastases: CT and MRI. Eur J Radiol 2000; 33: 230-8.
19. Kuna SK, Bracic I, Tesic V, Kuna K, Herceg GH, Dodig D. Ultrasonographic differentiation of benign from malignant neck lymphadenopathy in thyroid cancer. J Ultrasound Med 2006; 25: 1531-7; quiz 1538-40.
20. Stulak JM, Grant CS, Farley DR, et al. Value of preoperative ultrasonography in the surgical management of initial and reoperative papillary thyroid cancer. Arch Surg 2006; 141: 489-94; discussion 494-6.
21. Leboulleux S, Girard E, Rose M, et al. Ultrasound criteria of malignancy for cervical lymph nodes in patients followed up for differentiated thyroid cancer. J Clin Endocrinol Metab 2007; 92: 3590-4.
22. Ahn JE, Lee JH, Yi JS, et al. Diagnostic accuracy of CT and ultrasonography for evaluating metastatic cervical lymph nodes in patients with thyroid cancer. World J Surg 2008; 32: 1552-8.
23. Choi JS, Kim J, Kwak JY, Kim MJ, Chang HS, Kim EK. Preoperative staging of papillary thyroid carcinoma: comparison of ultrasound imaging and CT. AJR Am J Roentgenol 2009; 193: 871-8.
24. Choi WH, Chung YA, Han EJ, Sohn HS, Lee SH. Clinical value of integrated [18F]fluoro-2-deoxy-D-glucose positron emission tomography/computed tomography in the preoperative assessment of papillary thyroid carcinoma: comparison with sonography. J Ultrasound Med 2011; 30: 1267-73.
25. Choi YJ, Yun JS, Kook SH, Jung EC, Park YL. Clinical and imaging assessment of cervical lymph node metastasis in papillary thyroid carcinomas. World J Surg 2010; 34: 1494-9.
26. Jeong HS, Baek CH, Son YI, et al. Integrated 18F-FDG PET/CT for the initial evaluation of cervical node level of patients with papillary thyroid carcinoma: comparison with ultrasound and contrast-enhanced CT. Clin Endocrinol (Oxf) 2006; 65: 402-7.
27. Lee DW, Ji YB, Sung ES, et al. Roles of ultrasonography and computed tomography in the surgical management of cervical lymph node metastases in papillary thyroid carcinoma. Eur J Surg Oncol 2013; 39: 191-6.
28. Li Q. Value of color Doppler ultrasound and CT applied to diagnosis of thyroid carcinoma. J Minim Inv Med 2018; 13: 468-70.
29. Seo YL, Yoon DY, Baek S, et al. Detection of neck recurrence in patients with differentiated thyroid cancer: comparison of ultrasound, contrast-enhanced CT and (18) F-FDG PET/CT using surgical pathology as a reference standard: (ultrasound vs. CT vs. (18)F-FDG PET/CT in recurrent thyroid cancer). Eur Radiol 2012; 22: 2246-54.
30. Yoon DY, Hwang HS, Chang SK, et al. CT, MR, US,18F-FDG PET/CT, and their combined use for the assessment of cervical lymph node metastases in squamous cell carcinoma of the head and neck. Eur Radiol 2009; 19: 634-42.
31. Kim E, Park JS, Son KR, Kim JH, Jeon SJ, Na DG. Preoperative diagnosis of cervical metastatic lymph nodes in papillary thyroid carcinoma: comparison of ultrasound, computed tomography, and combined ultrasound with computed tomography. Thyroid 2008; 18: 411-8.

32. Caron NR, Tan YY, Ogilvie JB, et al. Selective modified radical neck dissection for papillary thyroid cancer-is level I, II and V dissection always necessary? World J Surg 2006; 30: 833-40.
33. Sywak M, Cornford L, Roach P, Stalberg P, Sidhu S, Delbridge L. Routine ipsilateral level VI lymphadenectomy reduces postoperative thyroglobulin levels in papillary thyroid cancer. Surgery 2006; 140: 1000-5; discussion 1005-7.
34. Son YI, Jeong HS, Baek CH, et al. Extent of prophylactic lymph node dissection in the central neck area of the patients with papillary thyroid carcinoma: comparison of limited versus comprehensive lymph node dissection in a 2-year safety study. Ann Surg Oncol 2008; 15: 2020-6.
35. Atula TS, Varpula MJ, Kurki TJ, Klemi PJ, Grenman R. Assessment of cervical lymph node status in head and neck cancer patients: palpation, computed tomography and low field magnetic resonance imaging compared with ultrasound-guided fine-needle aspiration cytology. Eur J Radiol 1997; 25: 152-61.
36. Short SO, Kaplan JN, Laramore GE, Cummings CW. Shoulder pain and function after neck dissection with or without preservation of the spinal accessory nerve. Am J Surg 1984; 148: 478-82.