Supplementary

Table S1 Full items synthesized through the cognitive task analysis (full list)

Section	CTA items
MID phase	*Identification of midline*
	Find the correct midline position in the strap muscles
	Retract midline bilaterally with both graspers
	When retracting the midline with graspers on both sides, give proper symmetrical tension and cautions for muscle tearing
	Midline incision
	Follow the surgical plane well and dissect it
	Identify the sternothyroid muscle and sternohyoid muscle
	Ensure sufficient incision to Delphian lymph node
	Caution of muscle injury when midline incision is made
	Incision from the thyroid cartridge to the suprasternal notch (or the location where central node dissection is possible)
	Identification of trachea
	Beware trachea injury
	Implement trachea exposure as much as possible
	Identification of isthmus
	Beware trachea injury
	Find isthmus well
	Whether you see the isthmus as soon as you open the midline from the sternohyroid muscle
	Isthmectomy
	Preserve the inferior thyroid vein on the non-operative side
	Consider the location of isthmus
	Beware vessel injury (such as thyroid ima)
	Beware cricoid cartilage injury
	Whether the left and right sides of the thyroid is separated
	Other items related to midline incision and isthmectomy
	Whether the isthmectomy is possible preoperatively (if there is a cancer on the isthmus itself, the isthmectomy position might be changed)
LAT phase	*Dissection of surgical plane between thyroid and strap muscle*
	Separate strap muscles and thyroid gland from cranial to caudal
	Dissect the surgical plane as close as possible to the surface of thyroid gland
	Be careful between thyroid gland and strap muscle
	Whether the strap muscle is injured
	Lateral retraction of the strap muscle
	Sufficiently separate the thyroid from the strap muscle
	Be careful if you pull the strap muscle excessively, it can tear and bleed

Table S1 (*continued*)

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Table S1 (*continued*)

Section	CTA items
	Identification of common carotid artery
	Identify the correct depth and course of the common carotid artery
	Leave the blood vessels around common carotid artery
	Whether the common carotid artery moves well according to the heartbeat
	Whether the common carotid artery is well exposed along the thyroid gland
	Thyroid retraction—lower
	Accurately locate parathyroid gland and RLN
	Beware of bleeding in thyroid capsule
	Expose the lower pole and part of the upper part of the thyroid gland
	Switching motion to support and lift the thyroid gland to check the tissue around the common carotid artery
	Other items related to lateral dissection
	Whether the central lymph nodes is removed cleanly along the thyroid gland
	Whether the middle thyroid vein is exposed and ligated certainly
INF phase	*Identification of RLN*
	Identify RLN between central lymph nodes
	Ensure safe distances considering the range of heat conduction in order to prevent thermal injury
	Retracting the thyroid gland excessively may cause mechanical injury of RLN
	Identify the course and the location of RLN
	Identification of inferior parathyroid gland
	Recognize the typical location and shape of parathyroid gland
	Identify the color of parathyroid gland
	Identify the anatomical mutations in the location of parathyroid gland
	Identify the blood stream distribution and blood vessel travel of parathyroid gland
	Determine whether to leave parathyroid or auto-transplantation after removal
	When the distinction between lymph nodes and parathyroid is difficult, determine whether to leave some or remove all depending on the cancer stage
	Beware of damage to parathyroid gland and the blood vessels leading to the parathyroid
	Preservation of the blood stream of parathyroid
	Preserve blood vessels that affect parathyroid
	Ensure safe distances considering the range of heat conduction to prevent thermal injury
	Identify inferior thyroidal vein and middle thyroidal vein
	Preserve parathyroid as much as possible
	Beware injury to parathyroid and parathyroid feeding vessels

Table S1 (*continued*)

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Table S1 (*continued*)

Section	CTA items
	Other items to preservation of inferior parathyroid glands
	Avoid retracting the parathyroid directly to prevent damage to the parathyroid
	If inevitable, retract tissues around the parathyroid or grab the blood vessels going to the parathyroid
BER phase	*Dissection between medial thyroid and trachea*
	Separate trachea and cricothyroid muscle from the thyroid gland
	Dissection between thyroid gland and fascia
	Finish the lateral dissection on the lateral side of the thyroid gland
	Thyroid retraction—Zuckerkandl
	Retract the thyroid in favor of entering the harmonic
	Beware of RLN injury caused by traction
	Preservation of RLN
	Consider various shapes of RLN
	Continue to check RLN's course from view to view
	Distinguish artery from RLN
	Predict RLN location and angle
	When Berry ligament and RLN are placed together, which intensity will you pull to?
	Dissect RLN while protect it by covering it with gauze ball to prevent thermal or mechanical injury
	Strong retraction on the thyroid may damage the RLN
	Beware of thermal injury
	Occasionally non-recurrent laryngeal nerve exists that drives directly into the vagus nerve from the upper part of the subclavian artery and enters the larynx
	Nerve monitoring allows you to see the amplitude of the nerve when initially stimulated (whether the signal has been reduced by more than 50%)
	Dissection of ligament of Berry
	Expose Berry ligament sufficiently
	When Berry ligament and RLN are placed together, which intensity will you pull to?
	Dissect thyroid gland below Berry ligament
	Check the cricothyroid muscle in the upper area
	Minimize residual thyroid tissue: may leave microscopic amounts of thyroid tissue when the thyroid and the RLN are attached, or when the thyroid tissue is covering the RLN like ears
	Hemostasis is difficult if bleeding occurs in Berry ligament
	Whether you remove Berry ligament well while protecting RLN
	Other items related to preservation of RLN, dissection of the ligament of Berry
	Use compression method with energy or gauze ball in some cases for hemostasis

Table S1 (*continued*)

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Table S1 (*continued*)

Section	CTA items
SUP phase	*Dissection in the upward direction*
	To prevent EBSLN injury, proceed dissection as close to the thyroid as possible and at the same time ligate the upper thyroid artery well
	Beware of EBSLN injury
	Mapping the course of EBSLN using nerve monitoring
	Identification and preservation of superior parathyroid glands
	Be careful of bleeding during the ligation of superior thyroid artery because the op field is narrow
	Determine which blood vessels to leave
	Beware of upper parathyroid injury
	Identification and preservation of EBSLN
	Whether EBSLN functions
	Whether the signals come from the EBSLN while using nerve monitoring
	Whether the cricothyroid muscle has twitching
	Ligation of superior thyroid artery and vein
	Adjust robotic arms for better visibility
	Expose the superior thyroid artery well at once and ligate it at once
	Other items related to dissection of the thyroid upper pole
	Use nerve monitoring to identify vagus nerve (located close to carotid artery)
END phase	*Specimen out*
	If the thyroid is too large to remove, expand the Troca tunner site sufficiently
	Use a surgical lap bag to safely discharge specimen out of the op field to prevent the metastasize to other tissues
	Use of hemostatic dressing and anti-adhesion adjuvant
	Sewing strap muscles with running sutures during midline closure (cranial to caudal)
	Drain insertion and midline closure

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Table S2 Results of modified Delphi consensus on items required to perform robotic thyroidectomy (full list)

Final rank	Phase	Items	Round 1			Round 2	
			Mean (SD)	% rating over 5	Rank	Mean (SD)	% rating over 5
1	BER	Continue to check RLN's course from view to view	6.67 (0.64)	100	3	6.85 (0.65)	95
2	LAT	Accurately locate parathyroid gland and RLN	6.76 (0.61)	100	2	6.8 (0.68)	95
2	INF	Identify the course and the location of RLN	6.81 (0.50)	100	1	6.8 (0.51)	100
4	INF	Ensure safe distances considering the range of heat conduction in order to prevent thermal injury	6.67 (0.56)	100	3	6.7 (0.56)	100
5	SUP	To prevent EBSLN injury, proceed dissection as close to the thyroid as possible and at the same time ligate the upper thyroid artery well	6.52 (0.59)	100	6	6.55 (0.50)	100
6	MID	Whether the isthmectomy is possible preoperatively (if there is a cancer on the isthmus itself, the isthmectomy position might be changed)	6.38 (0.79)	100	12	6.5 (0.81)	95
6	BER	Beware of thermal injury	6.52 (0.66)	100	6	6.5 (0.50)	100
8	MID	Beware trachea injury	6.43 (0.85)	100	11	6.45 (0.67)	100
8	INF	Retracting the thyroid gland excessively may cause mechanical injury of RLN	6.19 (0.91)	90	20	6.45 (0.86)	95
8	BER	Beware of RLN injury caused by traction	6.48 (0.73)	100	10	6.45 (0.74)	100
11	BER	Strong retraction on the thyroid may damage the RLN	6.24 (0.87)	95	15	6.4 (0.66)	100
12	MID	Beware trachea injury	6.52 (0.85)	95	6	6.35 (0.57)	100
12	INF	Preserve parathyroid as much as possible	6.57 (0.49)	100	5	6.35 (0.85)	95
12	BER	Whether you remove Berry ligament well while protecting RLN	6.24 (1.11)	90	15	6.35 (0.57)	100
12	SUP	Beware of EBSLN injury	6.29 (0.82)	95	13	6.35 (0.79)	95
12	END	Use a surgical lap bag to safely discharge specimen out of the op field to prevent the metastasize to other tissues	6.52 (0.73)	95	6	6.35 (0.79)	95
17	BER	Consider various shapes of RLN	6.24 (1.11)	86	15	6.3 (0.71)	95
18	BER	Distinguish artery from RLN	6.00 (1.15)	90	27	6.25 (0.77)	100
18	SUP	Be careful of bleeding during the ligation of superior thyroid artery because the op field is narrow	6.19 (0.91)	95	20	6.25 (0.77)	95
20	INF	Preserve blood vessels that affect parathyroid	6.24 (0.68)	100	15	6.2 (0.75)	100
21	INF	Ensure safe distances considering the range of heat conduction to prevent thermal injury	6.00 (0.69)	100	27	6.15 (0.73)	100
22	BER	When Berry ligament and RLN are placed together, which intensity will you pull to?	6.00 (0.93)	95	27	6.1 (0.62)	100
23	INF	Beware of damage to parathyroid gland and the blood vessels leading to the parathyroid	6.05 (1.05)	90	26	6.05 (0.80)	95

Table S2 (*continued*)

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Table S2 (*continued*)

Final rank	Phase	Items	Round 1			Round 2	
			Mean (SD)	% rating over 5	Rank	Mean (SD)	% rating over 5
23	INF	Beware injury to parathyroid and parathyroid feeding vessels	6.29 (0.76)	100	13	6.05 (0.80)	95
23	SUP	Beware of upper parathyroid injury	6.24 (0.92)	95	15	6.05 (0.80)	95
26	BER	When Berry ligament and RLN are placed together, which intensity will you pull to?	5.90 (0.92)	95	33	6 (0.55)	100
27	INF	Identify the blood stream distribution and blood vessel travel of parathyroid gland	6.14 (1.17)	86	22	5.95 (0.97)	95
27	BER	Predict RLN location and angle	5.90 (1.02)	90	33	5.95 (0.74)	100
27	BER	Dissect RLN while protect it by covering it with gauze ball to prevent thermal or mechanical injury	6.00 (1.11)	86	27	5.95 (0.97)	90
27	END	If the thyroid is too large to remove, expand the Troca tunner site sufficiently	6.00 (0.87)	100	27	5.95 (0.59)	100
31	INF	Identify the color of parathyroid gland	6.10 (0.97)	90	24	5.9 (0.70)	95
31	BER	Expose Berry ligament sufficiently	5.95 (0.95)	90	32	5.9 (0.70)	95
33	INF	Recognize the typical location and shape of parathyroid gland	6.14 (0.99)	90	22	5.85 (0.73)	95
34	SUP	Adjust robotic arms for better visibility	6.10 (0.97)	90	24	5.8 (0.81)	90
35	INF	Determine whether to leave parathyroid or auto-transplantation after removal	5.90 (0.97)	90	33	5.7 (0.71)	95
35	SUP	Whether the cricothyroid muscle has twitching	5.86 (1.39)	90	37	5.7 (1.27)	95
37	BER	Minimize residual thyroid tissue: may leave microscopic amounts of thyroid tissue when the thyroid and the RLN are attached, or when the thyroid tissue is covering the RLN like ears	5.71 (0.98)	86	43	5.65 (0.73)	90
37	SUP	Whether EBSLN functions	5.76 (1.41)	90	38	5.65 (1.39)	90
39	MID	Follow the surgical plane well and dissect it	5.67 (1.32)	81	49	5.6 (0.80)	90
39	MID	Implement trachea exposure as much as possible	5.57 (1.09)	76	53	5.6 (0.66)	95
39	BER	Occasionally non-recurrent laryngeal nerve exists that drives directly into the vagus nerve from the upper part of the subclavian artery and enters the larynx	5.76 (1.11)	81	38	5.6 (0.73)	90
39	BER	Hemostasis is difficult if bleeding occurs in Berry ligament	5.57 (1.18)	76	53	5.6 (0.73)	90
39	SUP	Expose the superior thyroid artery well at once and ligate it at once	5.71 (1.12)	81	43	5.6 (0.86)	90
44	MID	Beware cricoid cartilage injury	5.67 (1.21)	86	49	5.55 (0.92)	85
44	LAT	Sufficiently separate the thyroid from the strap muscle	5.62 (0.79)	90	52	5.55 (0.59)	95

Table S2 (*continued*)

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Table S2 (*continued*)

Final rank	Phase	Items	Round 1			Round 2	
			Mean (SD)	% rating over 5	Rank	Mean (SD)	% rating over 5
44	LAT	Beware of bleeding in thyroid capsule	5.67 (0.89)	95	49	5.55 (0.80)	95
44	INF	Identify RLN between central lymph nodes	5.90 (1.19)	90	33	5.55 (0.92)	90
44	BER	Retract the thyroid in favor of entering the Harmonic	5.76 (0.92)	90	38	5.55 (0.80)	90
49	BER	Separate trachea and cricothyroid muscle from the thyroid gland	5.76 (1.06)	86	38	5.5 (0.67)	95
49	BER	Nerve monitoring allows you to see the amplitude of the nerve when initially stimulated (whether the signal has been reduced by more than 50%)	5.43 (1.43)	76	57	5.5 (1.28)	90
49	BER	Use compression method with energy or gauze ball in some cases for hemostasis	5.71 (0.93)	90	43	5.5 (0.81)	85
49	SUP	Determine which blood vessels to leave	5.48 (1.05)	81	55	5.5 (0.81)	90
53	BER	Check the cricothyroid muscle in the upper area	5.71 (1.03)	81	43	5.45 (0.86)	90
54	INF	Identify the anatomical mutations in the location of parathyroid gland	5.71 (1.08)	86	43	5.4 (0.92)	80
54	INF	When the distinction between lymph nodes and parathyroid is difficult, determine whether to leave some or remove all depending on the cancer stage	5.71 (0.98)	86	43	5.4 (0.80)	85
56	LAT	Be careful if you pull the strap muscle excessively, it can tear and bleed	5.14 (0.89)	76	64	5.35 (0.65)	90
56	LAT	Expose the lower pole and part of the upper part of the thyroid gland	5.29 (0.88)	81	62	5.35 (0.73)	90
56	BER	Dissect thyroid gland below Berry ligament	5.76 (0.97)	86	38	5.35 (0.85)	80
59	MID	Incision from the thyroid cartridge to the suprasternal notch (or the location where central node dissection is possible)	5.43 (1.18)	81	57	5.3 (0.78)	85
59	INF	If inevitable, retract tissues around the parathyroid or grab the blood vessels going to the parathyroid	5.24 (1.19)	67	63	5.3 (0.71)	85
61	MID	Find isthmus well	5.38 (0.84)	90	59	5.25 (0.70)	85
62	LAT	Identify the correct depth and course of the common carotid artery	5.48 (1.26)	81	55	5.2 (0.93)	85
63	LAT	Whether the middle thyroid vein is exposed and ligated certainly	5.38 (1.17)	86	59	5.15 (0.96)	80
63	SUP	Whether the signals come from the EBSLN while using nerve monitoring	5.38 (1.43)	81	59	5.15 (1.49)	80

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Table S3 Additional comments

Phase	Comments
MID	If only lobectomy is operated, the lateral approach could be considered
LAT	During the LAT phase, the direction of dissection is recommended to be cranial
BER	I think it is necessary to discuss whether continuous nerve monitoring should be applied to all patients
SUP	Try to identify EBSLN as possible
END	"Simple interrupted suture is recommended for midline closure because when there is op bed bleeding, you can secure golden time" and "Interrupted inverted suture is recommended because it can buy time by becoming window during bleeding"

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