The Content-Based Standardizing Nomenclatures (CBSN) in Radiotherapy for Nasopharyngeal carcinoma OARs

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INTRODUCTION

AAPM TG-263 (the American Association of pharmaceuticals in Medicine Task Group 263) puts forward a standardized report on nomenclature of radiation oncology, which is dedicated to the design and implementation of standardized radiotherapy plan. Among them, the standardization principle of naming target area and organ at risk (OARs) in radiotherapy structure, dose volume histogram specification and unity of units are described, which is conducive to reducing the confusion among staff caused by inconsistency and gradually becomes a new demand for radiotherapy practice[1-4].

AIM

Based on AAPM TG-263, a **Content-Based Standardizing Nomenclatures (CBSN)** was proposed to explore the feasibility of its standardization verification for OARs of nasopharyngeal carcinoma (NPC).

METHOD

Retrospectively collected and processed the radiotherapy structure files of 855 patients with NPC who underwent IMRT radiation treatment from 2017 to 2019 (15 of which included clinical abnormal structures). The MATLAB self-developed software was used to obtain the image position, geometric features, first-order gray histogram, and the Gray-level Co-occurrence Matrix (GLCM)′ s texture features of the OARs contour outlined by the doctor to establish the CBSN Location Verification model and CBSN Knowledge Library. Fisher discriminant analysis was used to establish a CBSN OAR classification model, and the model was evaluated using self-validation, Cross-validation, and external validation, respectively.

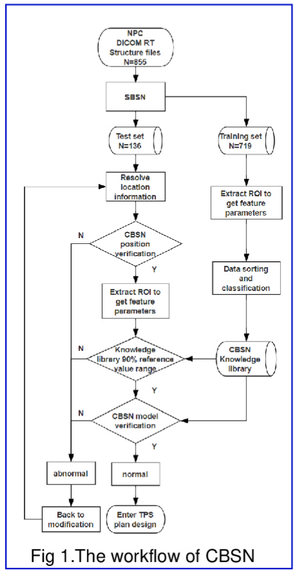

Fig 1.The workflow of CBSN

RESULTS

CBSN position verification

CBSN position verification can identify the following 4 types of abnormal structures: (1) Relative layer position abnormality: if the radiotherapy structure named Eye_R is located on the top layer of the head; (2) The left and right positions of the symmetrical structure are marked abnormally: if the right crystal named Len_L; (3) The radiotherapy structure is non-unique: such as the left and right crystals named Len_R; (4) Garbage points: such as the outline structure outside the outline, outlined in the air, not in the patient's body, etc. Of the 15 clinical abnormal structures collected, 14 were abnormal. The abnormal structures were more common in the eyeball and lens. The abnormal types were concentrated in the first and second categories, accounting for 40.00% and 33.30% respectively. CBSN location verification detected 13 cases of location abnormal structures, with an accuracy rate of 92.86% (13/14). In addition, the remaining one clinical abnormal structure does not belong to the location abnormality, and enters the next stage of CBSN knowledge library detection.

CBSN Knowledge library

There are 14950 OARs of 22 types in nasopharyngeal carcinoma. The 12 characteristic parameters obtained by CBSN are statistically significant in different OARs (asymmetric structures), P<0.001.The 90% reference value range (P_5~P_{95}) of the OARs characteristic parameters generated by the CBSN knowledge library is used as the standard for identifying abnormal structures. Of the 15 clinical abnormal structures, 14 belong to abnormal location, and the remaining one is due to the lack of structural layers. It entered the CBSN knowledge library for detection. The specifics are: the optic nerve is not completely delineated, and there is the possibility of missing the layer. Range comparison. Except for gray scale skewness, gray scale kurtosis and GLCM energy, all the characteristic values are outside the reference value range of the CBSN knowledge library, that is, the characteristics of the structure are at <P_5 or >P_{95}.

Tab. 1 Knowledge based library (P_5~P_{95})

Knowledge based library (P_5~P_{95})													
	OAR	Volume (cm^3)	Slices	CT (HU)	GrayMin	GrayMax	Gray Std	Gray Skewness	Gray Kurtosis	GLCM Contrast	GLCM Homogeneity	GLCM Correlation	GLCM Energy
1	Brainstem	(22.23~36.21)	(18~24)	(23.28~29.78)	(976~1015)	(1080~1382)	(8.64~14.05)	(-1.33~3.96)	(3.28~107.02)	(20.28~28.11)	(0.88~0.91)	(0.67~0.76)	(0.49~0.56)
2	Eye_L	(6.59~12.44)	(7~11)	(13.2~55.15)	(512.9~1004)	(1106~2290.95)	(14.93~158.73)	(-2.89~3.99)	(3.06~59.81)	(19.14~30.41)	(0.82~0.88)	(0.64~0.74)	(0.29~0.46)
3	Eye_R	(6.52~12.61)	(7~11)	(14.45~71.12)	(403~1012.05)	(1108.95~2374.75)	(15.65~140.29)	(-2.5~7.31)	(2.88~107.55)	(18.61~29.28)	(0.82~0.88)	(0.65~0.74)	(0.27~0.45)
4	Glnd_Parotid_L	(17.45~44.4)	(16~23)	(-24.21~53.44)	(808.25~943)	(1891~2719.25)	(39.36~132.18)	(4.16~11.14)	(46.02~198.43)	(9.76~20.73)	(0.85~0.90)	(0.75~0.86)	(0.27~0.35)
5	Glnd_Parotid_R	(17.83~47.21)	(16~22)	(-27.55~50.04)	(82~916)	(1704.75~2694.25)	(35.32~141.31)	(0.72~11.62)	(30.29~223.93)	(10.48~21.56)	(0.85~0.89)	(0.75~0.85)	(0.27~0.35)
6	Glnd_Pituitary	(0.08~0.57)	(2~3)	(7.78~83.05)	(642~1051)	(1064~1504)	(9.97~91.62)	(-1.56~3.65)	(1.97~25.12)	(34.03~76.47)	(0.66~0.81)	(0.24~0.56)	(0.21~0.45)
7	InnerEar_L	(0.49~3.24)	(2.6~5)	(475.63~1160.31)	(24~1123.2)	(2408.2~2930.8)	(339.29~570.85)	(-0.89~0.53)	(1.97~3.64)	(10.29~52.64)	(0.52~0.68)	(0.26~0.83)	(0.07~0.16)
8	InnerEar_R	(0.75~3.23)	(3~5)	(459.73~1138.41)	(24~1115.4)	(2518.2~2937.4)	(349.59~651.41)	(-1.09~0.88)	(2.04~4.09)	(10.64~49.26)	(0.53~0.66)	(0.27~0.83)	(0.07~0.14)
9	Larynx	(27.5~78.05)	(15~25)	(-285.41~81.28)	(24~41)	(1507~2275.5)	(330.63~463.45)	(-1.77~-0.64)	(1.74~5.02)	(9.37~20.1)	(0.70~0.80)	(0.73~0.84)	(0.14~0.21)
10	Len_L	(0.07~0.32)	(2~4)	(32.2~103.84)	(1016~1086.3)	(1103~1175)	(19.25~28.07)	(-0.3~0.68)	(1.74~2.99)	(55.21~95.05)	(0.60~0.75)	(0.14~0.44)	(0.28~0.40)
11	Len_R	(0.08~0.33)	(2~4)	(30.29~105.78)	(1016~1090.3)	(1103~1175)	(18.61~27.35)	(-0.24~0.7)	(1.69~2.9)	(55.94~95.8)	(0.60~0.75)	(0.12~0.44)	(0.27~0.41)
12	Mandible_L	(33.98~58.89)	(26~35)	(529.5~817.66)	(107.5~949)	(2546~4021.2)	(407.41~556.1)	(-0.08~0.6)	(1.65~2.65)	(7.29~14.89)	(0.68~0.75)	(0.70~0.87)	(0.21~0.33)
13	Mandible_R	(34.12~59.21)	(26~35)	(516.47~789.48)	(124.9~944)	(2540.4~4000)	(418.95~567.96)	(-0.06~0.64)	(1.61~2.74)	(7.79~14.92)	(0.68~0.75)	(0.76~0.86)	(0.22~0.32)
14	OpticChiasm	(0.17~1.57)	(2~4)	(16.75~100.96)	(439.05~1025.05)	(1105.9~1818.3)	(13.27~141.6)	(-0.66~5.13)	(3.34~39.87)	(15.73~71.21)	(0.66~0.86)	(0.39~0.75)	(0.23~0.41)
15	OpticNerve_L	(0.17~0.79)	(2~3)	(-36.09~21.68)	(689.8~956)	(1061~1621)	(29.29~105.24)	(-1~3.34)	(1.68~23.59)	(21.12~63.18)	(0.70~0.86)	(0.42~0.72)	(0.26~0.50)
16	OpticNerve_R	(0.17~0.76)	(2~3)	(-30.46~18.7)	(904.8~963)	(1061~1397.2)	(25.25~63.77)	(-0.96~2.14)	(1.73~11.2)	(22.2~61.58)	(0.72~0.87)	(0.45~0.73)	(0.27~0.49)
17	SpinalCord	(10.93~27.24)	(44~69)	(0.61~44.67)	(841~982)	(1252~2026)	(18.68~81.46)	(-0.27~8.27)	(9.69~124.37)	(32.05~49.13)	(0.77~0.84)	(0.46~0.59)	(0.33~0.45)
18	TemporalLobe_L	(67.08~127.89)	(14~20)	(30.33~42.16)	(709.6~1020)	(1488.7~2281.6)	(13.71~45.65)	(6.37~18.64)	(82.67~570.76)	(6.44~13.29)	(0.91~0.94)	(0.84~0.89)	(0.38~0.48)
19	TemporalLobe_R	(68.65~129.8)	(14~20)	(36.15~57.71)	(623.4~1020)	(1978.4~2516.3)	(40.99~116.73)	(5.96~12.09)	(44.38~201.01)	(5.14~12.63)	(0.91~0.94)	(0.83~0.89)	(0.38~0.47)
20	TMjoint_L	(0.92~3.34)	(2~5)	(352.58~590.58)	(461~1085.6)	(2063.4~2552.6)	(208.06~361.79)	(-0.03~0.91)	(2.05~4.03)	(12.43~26.3)	(0.62~0.70)	(0.55~0.72)	(0.06~0.11)
21	TMjoint_R	(0.92~3.43)	(2~5)	(336.87~583.67)	(574.4~1060)	(2103~2562.6)	(215.78~375.27)	(0.13~1.01)	(2.08~3.92)	(10.76~26.19)	(0.62~0.70)	(0.57~0.73)	(0.06~0.12)
22	Tongue	(42.17~135.85)	(12~25)	(-17.45~254.85)	(24~943)	(1844.5~4035.75)	(34.34~514.74)	(-2.89~13.08)	(6.55~285.09)	(4.08~14.73)	(0.84~0.92)	(0.76~0.87)	(0.28~0.47)

CBSN organ classification model

The accuracy rates of Self-verification, Cross-validation and External verification of the CBSN endangered organ classification model are: 92.10%, 92.00% and 91.84%, respectively. In Self-verification, Cross-validation and External verification, the accuracy rate of 11 types of 14 types of OARs is more than 80.00%, of which OARs such as Brainstem and SpinalCord are more than 95.00%. Some nasopharyngeal carcinomas have low accuracy of small-volume OARs, such as OpticChiasm and Glnd_Pituitary, self-validation and Cross-validation: 77.10% and 63.30%, external validation: 80.00% and 59.60%, and the largest misclassification categories are OpticNerve and Len, respectively.

Tab.2 CBSN organ classification model

OAR (Yn)		Self-verification			Cross-validation			External verification		
		Accuracy (%)	Maximum misclassification ratio(%)	N	Accuracy (%)	Maximum misclassification ratio(%)	N	Accuracy (%)	Maximum misclassification ratio(%)	N
Y_1	Brainstem	98.70	1.30(Y_3)	719	98.70	1.30(Y_3)	719	97.40	2.50(Y_3)	119
Y_2	Eye_L/Eye_R	96.90	1.60(Y_3)	1156	96.90	1.60(Y_3)	1156	97.50	0.90(Y_1,Y_9)	206
Y_3	Glnd_Parotid_L/Glnd_Parotid_R	98.90	1.10(Y_2)	1428	98.90	1.10(Y_2)	1428	98.30	1.60(Y_2)	242
Y_4	Glnd_Pituitary	63.30	19.10(Y_7)	559	63.30	19.10(Y_7)	559	59.60	23.00(Y_7)	104
Y_5	InnerEar_L/InnerEar_R	92.10	7.50(Y_{13})	1422	92.10	7.50(Y_{13})	1422	90.50	7.60(Y_{13})	234
Y_6	Larynx	99.20	0.50(Y_2)	629	99.20	0.50(Y_2)	629	100.00	0.00	92
Y_7	Len_L/Len_R	82.30	16.80(Y_4)	1426	82.30	16.80(Y_4)	1426	82.50	15.70(Y_4)	241
Y_8	Mandible_L/Mandible_R	99.90	0.10(Y_{13})	1402	99.90	0.10(Y_{13})	1402	100.00	0.00	228
Y_9	OpticChiasm	77.10	15.00(Y_{10})	638	77.10	15.00(Y_{10})	638	80.00	10.80(Y_{10})	120
Y_{10}	OpticNerve_L/OpticNerve_R	78.60	12.60(Y_9)	1430	78.50	12.70(Y_9)	1430	79.60	15.60(Y_9)	236
Y_{11}	SpinalCord	100.00	0.00	719	100.00	0.00	719	100.00	0.00	120
Y_{12}	TemporalLobe_L/TemporalLobe_R	99.00	0.50(Y_{14})	1434	98.90	0.60(Y_{14})	1434	98.30	0.80(Y_1)	238
Y_{13}	TMjoint_L/TMjoint_R	99.90	0.10(Y_4,Y_5)	1414	99.90	0.10(Y_4,Y_5)	1414	100.00	0.00	236
Y_{14}	Tongue	85.90	6.80(Y_{12})	574	85.70	7.00(Y_{12})	574	87.90	7.20(Y_{12})	83
	Total	92.10	7.90	14950	92.00	8.00	14950	91.84	8.16	2499

CONCLUSIONS

Based on AAPM TG-263, the content-based radiotherapy structure naming standardization was proposed, and the successful verification of nasopharyngeal cancer organs and the identification of abnormal structures were successfully achieved. CBSN provides a reference for multi-center cooperation and standardized radiotherapy of nasopharyngeal carcinoma. Clinicians can detect abnormal structures according to the CBSN method to improve the quality and safety of radiotherapy.

REFERENCES

1 **Santanam L, Hurkmans C, Mutic S, et al.** Standardizing Naming Conventions in Radiation Oncology. *International Journal of Radiation Oncology Biology Physics, 2012, 83(4): 1344–1349. DOI:10.1016/j.ijrobp.2011.09.054.*

2 **MATUSZAK M, MORAN J, XIAO Y, et al.** SU-E-P-22: AAPM Task Group 263 Tackling Standardization of Nomenclature for Radiation Therapy. *Med Phys, 2015, 42(6Part4):3231-3231. DOI: 10.1118/1.4923956.*

3 **Mayo C S, Moran J M, BOSCH W R, et al.** AAPM TG-263: Standardizing Nomenclatures in Radiation Oncology. *International Journal of Radiation Oncology*Biology*Physics, 2017, 100(4):1057-1066. DOI: 10.1016/j.ijrobp.2017.12.013.*

4 **Mayo C S, Moran J M, BOSCH W R, et al.** Report no. 263-Standardizing nomenclatures in Radiation Oncology[R]. 2018. *https://www.aapm.org/pubs/reports/detail.asp?docid=171.*

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