The effect of two different methods of planning landing zone for left atrial appendage closure by cardiac computed tomography angiography: a comparative study

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Background: To explore the value of 2 different methods for planning landing zone for left atrial appendage closure (LAAC) by cardiac computed tomography angiography (CCTA).

Methods: A retrospective analysis was performed on the clinical data of patients who successfully underwent LAAC with the Watchman device at The Affiliated Taizhou People's Hospital of Nanjing Medical University from August 2020 to February 2022. Two different methods were used to plan the landing zone and measure the longest diameter, average diameter, depth, and perimeter of the landing zone. The difference between the 2 methods and the correlation between their measurements and occluder size were analyzed.

Results: A total of 66 patients undergoing LAAC were included, with an average age of 69.35±7.1 years, of whom 30 (45.5%) were women. The mean error between the longest diameter measured by the traditional method and the actual value was 2.90±2.83 mm, and the mean absolute error (MAE) was 2.71 (1.17, 4.38) mm. The mean error between the longest diameter measured by the new method and the actual value was 0.9 (−0.13, 2.50) mm, and its MAE was 1.4 (0.40, 2.53) mm. The error of the longest diameter measured by the traditional method was larger than that measured by the new method (P<0.001). The mean error between the depth measured by the traditional method and the actual value was 1.40±3.45 mm, and the MAE was 2.36 (0.74, 4.58) mm. The mean error between the depth measured by the new method and the actual value was 0.10 (−1.33, 1.95) mm, and the MAE was 1.55 (0.60, 3.10) mm. Likewise, the depth error measured by the traditional method was larger than that measured by the new method (P<0.05). The correlation between the perimeter and the size of the occluder was the strongest (r=0.919, P<0.001).

Conclusions: With CCTA, the new method is more accurate in planning landing zone than the traditional method. It is particularly important to select the occluder size for the patients with flat oval landing zone ostium.

Keywords: Atrial fibrillation (AF); left atrial appendage closure (LAAC); occluder; perimeter of landing zone

Submitted Nov 16, 2022. Accepted for publication Jan 03, 2023. Published online Jan 31, 2023.
doi: 10.21037/atm-22-6183
View this article at: https://dx.doi.org/10.21037/atm-22-6183

Introduction

Atrial fibrillation (AF), the most common arrhythmia, has an increasing prevalence with age and poses a 5-fold increased risk of stroke compared to the general population (1). Over 90% of embolic strokes are attributed to a thrombus in the left atrial appendage (LAA) (2). Although the conventional oral anticoagulant administration effectively lowers the risk of thromboembolism, it increases the risk of bleeding. Nearly 50% of patients are intolerant of oral anticoagulants (3). Left atrial appendage closure (LAAC) can be considered as an effective treatment for patients with non-valvular AF who have both high risk of stroke and contraindication to oral anticoagulants (4). At present, the Watchman device (Boston Scientific, Marlborough, MA, USA) is widely used for LAAC in clinical practice. Reasonable preoperative planning and appropriate selection of an occluder are essential to improve the success rate of surgery and reduce postoperative complications. Transesophageal echocardiography (TEE), which is invasive and poorly tolerated by patients, along with disadvantages such as low spatial and image resolution, is used for routine preoperative evaluation of LAA in the past. A study has confirmed that the measurements of cardiac computed tomography angiography (CCTA) correlate well with the size of the Watchman device, and CCTA are superior to TEE in assessing the size of LAA preoperatively (5). Currently, the Watchman device size is mainly selected with reference to the longest diameter of landing zone, and the diameter of LAA opening calculated from the perimeter has been shown to be the best parameter for determining the size of the Watchman occluder device (6). However, the above studies defined the landing zone of LAA as a line connecting the left circumflex coronary artery and 1–2 cm inside Coumadin ridge to the left superior pulmonary vein (PV). However, the LAA has a high variability, and the actual landing zone of a significant proportion of patients is inconsistent with the zone planned by the traditional method. Therefore, this study aimed to find a more suitable method than the traditional method to guide LAAC based on individualized planning landing zone for the specific morphological characteristics of LAA by CCTA, so as to provide reference for clinical work. We present the following article in accordance with the STROBE reporting checklist (available at https://atm.amegroups.com/article/view/10.21037/atm-22-6183/rc).

Highlight box

Key findings

- It is especially important to select the occluder size for patients with flat oval ostium of the landing zone, and the landing zone perimeter measured by the new method is most strongly correlated with the occluder size.

What is known and what is new?

- AF is the most common arrhythmia and at present, and the Watchman device has been widely used for LAAC in clinical practice.
- This study aimed to find a more suitable method than the traditional method to guide LAAC based on individualized planning landing zone for the specific morphological characteristics of LAA by CCTA.

What is the implication, and what should change now?

- Two different methods were used to plan the landing zone and measure the longest diameter, average diameter, depth, and perimeter of the landing zone. The difference between the two methods and the correlation between their measurements and occluder size were analyzed.

Methods

Participants

A total of 66 patients who successfully underwent LAAC using Watchman occluder device (Poco, Natick, Massachusetts, USA) at The Affiliated Taizhou People's Hospital of Nanjing Medical University from August 2020 to February 2022 were included in this single-center trial. The exclusion criteria were as follows: (I) patients who did not undergo CCTA before surgery; (II) patients who developed cardiac tamponade during surgery; (III) patients who had device-related thrombosis (DRT), residual shunt ≥5 mm in the occluder or occluder displacement during CCTA or TEE follow-up 3 months after surgery; (IV) and patients with ischemic stroke during postoperative follow-up. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by ethics board of The Affiliated Taizhou People's Hospital of Nanjing Medical University (No. KY-2021-080-01) and informed consent was taken from all the patients.

CT image acquisition

Patients were scanned with a dual-source CT scanner (Siemens SOMATOM Force; Siemens Healthineers, Erlangen, Germany), with iopromide as the contrast medium. A total of 50 mL of iopromide (370 mgI/mL) was injected into the antecubital vein using a high-pressure syringe at a flow rate of 4.0 mL/s, followed by 40 mL of normal saline. An adaptive prospective electrocardiogram (ECG)-triggered cardio sequence scanning (Adapt sequence) was used for CT; automatic dynamic real-time X-ray dose control technology (CareDose 4D; Siemens) was used for tube current adjustment, with an exposure dosage range (ECG pulsing) of 30–80% R-R interval. Intelligent optimum tube voltage technology (Care kV; Siemens) was also adopted for CT, with a collimation of 192×0.6 mm, a field of view (FOV) of 150 mm × 150 mm – 180 mm × 180 mm, an automatic adjustment of pitch (P=0.2–0.5) following the changes of heart rate, and a scanning range from 1 cm below the tracheal carina to the diaphragmatic surface of the heart.

CT image analysis

Data were imported into the Syngo VB10 workstation (Siemens) and image analysis was performed using MM Reading software (Berlin, Germany).

The traditional method of landing zone measurement by CCTA: multiplanar cardiac reformat (MPR) was used for the reconstruction of LAA systolic images. The line connecting 1–2 cm inside Coumadin ridge to the left superior PV and the left circumflex coronary artery was defined as the landing zone of LAA. An orthogonal view of the landing zone was generated through adjusting the crosshair at this zone, and the longest diameter, shortest diameter, as well as perimeter of the landing zone were measured according to this view. The depth of the landing zone was the distance from the midpoint of the landing zone to the tip of the LAA.

The new method of landing zone measurement by CCTA: (I) volume rendering (VR) technique was adopted for the reconstruction of LAA. LAA was rotated to the appropriate working position with the rotation angle determined by the morphology and axial direction of LAA, in order to fully expose the LAA neck as well as the spatial distribution of each the left atrial appendage neck and each lobe. (II) With the help of VR or maximal intensity projection (MIP) technique, the landing zone position was jointly predicted by the surgeon and the radiologist in view of the morphology, axial direction, and pectinate muscle distribution of LAA at the optimal deployment angle, and the opening width and depth of the landing zone were measured.

The selection of the landing zone abided by the following principles: (I) The occluder could be stably released in this zone, the barbs at the distal end of the occluder were fully embedded in the pectinate muscle, and occluder displacement or detachment was easily avoided. (II) The inner diameter and depth of this zone accommodated less occurrence of atrial appendage rupture. (III) Under the premise of meeting the above 2 points, the landing zone was as close to the LAA opening as possible, so that each lobe was as completely occluded as possible. The depth was defined as the maximum distance from the midpoint of the diameter in the landing zone to the position of LAA that can be reach by the occluder down the predetermined axis. (IV) The cross-sectional morphology of the landing zone was displayed under MPR, and the longest diameter, shortest diameter, and perimeter of LAA were measured, and finally the average diameter was calculated. (V) The axial direction of the occluder after implantation was estimated and the relationship between the opening and distal pectinate muscles of LAA (*Figures 1,2*).

Statistical analysis

The software SPSS 26.0 (IBM Corp., Armonk, NY, USA) was used for statistical analysis. If continuous variables conformed to the normal distribution, they were described in the form of mean ± standard deviation (SD); if not, they were described in the form of M (1/4, 3/4). If comparisons between the 2 groups conformed to the normal distribution, they were analyzed using the paired sample *t*-test; if not, the Wilcoxon test was applied. Spearman correlation analysis was applied to evaluate the correlation between the parameters of the landing zone measured by the traditional and new methods under CCTA and the actual model of the occluder, with the correlation coefficients (r) 0.8–1.0 being extremely strongly correlated, 0.6–0.8 being strongly correlated, 0.4–0.6 being moderately correlated, and 0.2–0.4 being weakly correlated. All results were considered statistically significant at P<0.05 (two-sided).

Results

Patient profile

A total of 66 patients with a mean age of 69.35±7.1 years and 30 (45.5%) females were included in this study. The mean CHA_2DS_2-VASc [congestive heart failure, hypertension, age ≥75 (doubled), diabetes, stroke (doubled), vascular disease, age 65 to 74 and sex category (female)] score was 3.76±1.36 and the mean HAS-BLED [hypertension,

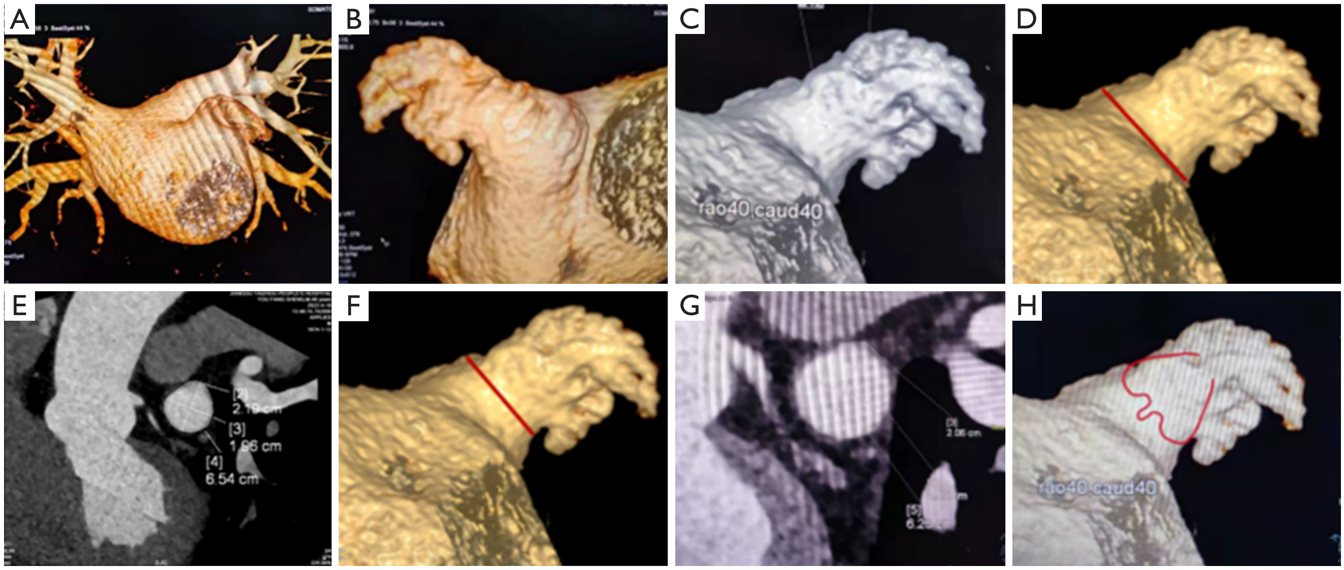

Figure 1 Long neck type of LAA. (A-C) VR results of LAA at different angles; (D) landing zone (referring to the red line area where the distal end of the occluder was insufficiently hooked to the pectinate muscle after deployment and the occluder was displaced after traction) planned by the traditional method; (E) the cross-sectional morphology of the landing zone under the traditional method; (F) landing zone (referring to the red line area) planned by the new method; (G) the cross-sectional morphology of the landing zone under the new method; (H) simulation of occluder release under VR (the red pattern represents the occluder). LAA, left atrial appendage; VR, volume rendering.

abnormal renal/liver function, stroke, bleeding history or predisposition, labile INR (international normalized ratio), elderly, drugs/alcohol concomitantly] score was 4.46±0.65. Chronic AF was present in 50 patients (75.8%) and paroxysmal AF in 16 patients (24.2%). Cauliflower type of LAA was present in 26 cases (39.4%), chicken wing type in 22 cases (33.3%), cactus type in 10 cases (15.2%), and windsock type in 8 cases (12.1%).

The parameters of landing zone planned by two methods under CCTA

The longest diameter of the LAA measured by the traditional method was 27.97 (23.73, 29.96) mm, the depth was 26.25 (22.05, 29.39) mm, the average diameter was 25.86 (22.05, 27.41) mm, and the perimeter was 78.85±12.35 mm. As for the measurements of the new method, the longest diameter was 25.11±3.61 mm, the depth was 24.33±4.38 mm, the average diameter was 23.73 (20.99, 25.43) mm, and the perimeter was 74.80±11.07 mm. Under the intraoperative fluoroscopy, the actual longest diameter was 24.5 (21.0, 26.0) mm and the depth was 24.0 (22.0, 27.0) mm. All parameters measured by the traditional method were overall larger than those measured by the new method ($P<0.05$); the longest diameter and depth measured by the traditional method were larger than the actual value ($P<0.05$). With the new method, the measured longest diameter was larger than the actual value ($P<0.05$), but the measured depth was close to the actual value ($P>0.05$) (*Table 1*).

The mean error between the longest diameter measured by the traditional method and the actual value was 2.90±2.83 mm, with the mean absolute error (MAE) of 2.71 (1.17, 4.38) mm. The mean error between the longest diameter measured by the new method and the actual value was 0.9 (–0.13, 2.50) mm, with the MAE of 1.4 (0.40, 2.53) mm. Accordingly, the error of the longest diameter measured by the traditional method was bigger than that measured by the new method, which was statistically different ($P<0.001$). The mean error between the measured depth by the traditional method and the actual value was 1.40±3.45 mm, with the MAE of 2.36 (0.74, 4.58) mm; the mean error between the measured depth by the new method and the actual value was 0.10 (–1.33, 1.95) mm, with the MAE of 1.55 (0.60, 3.10) mm. Likewise, the measured depth error by the traditional method was larger than that by the new method, which was also statistically different ($P<0.05$) (*Table 2*).

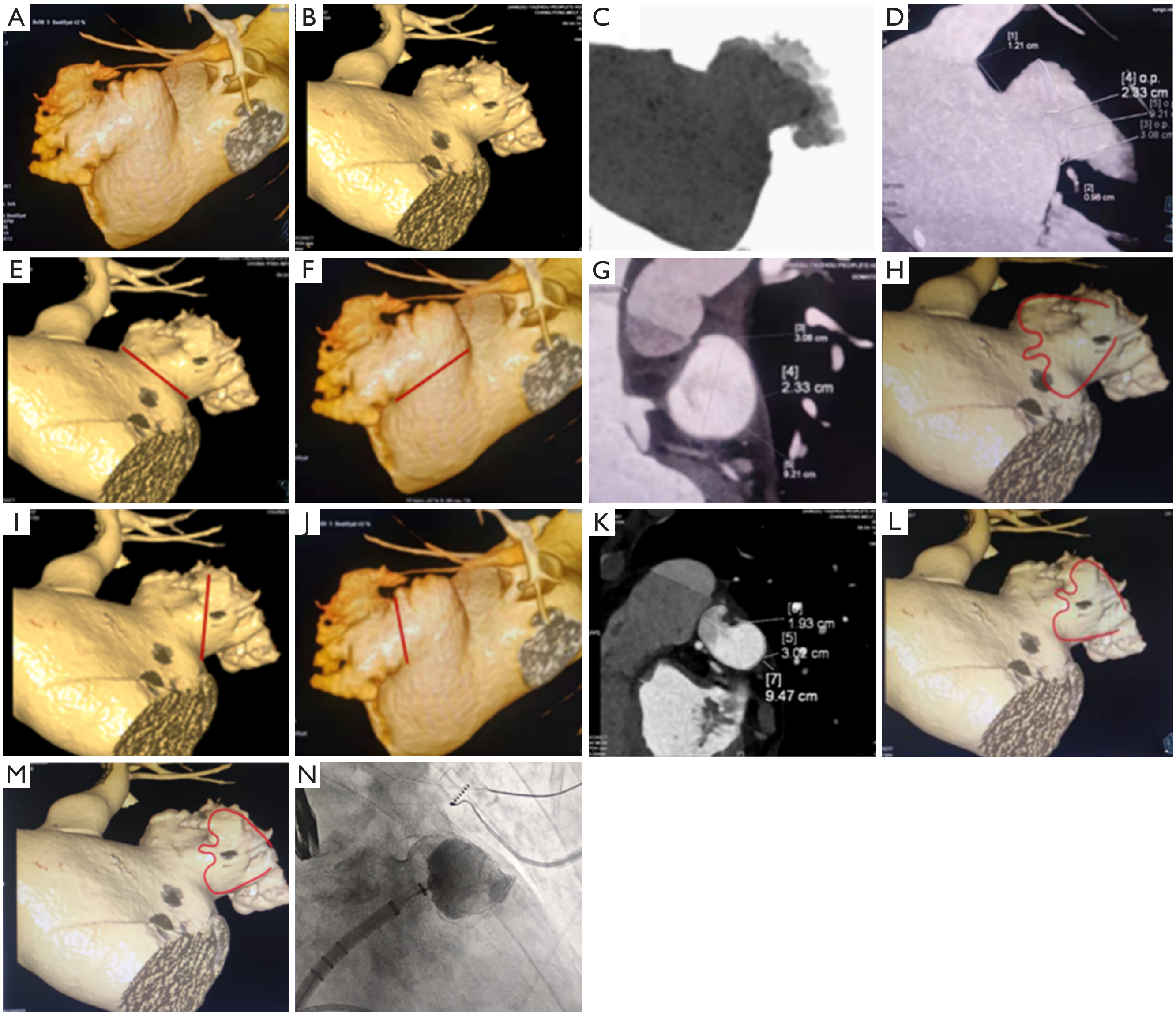

Figure 2 Complex chicken wing type of LAA. (A,B) VR results of LAA at different angles; (C) LAA displayed under MIP; (D) MPR results of LAA's main lobe. (E-H): E and F referring to the red line area where the distal end of the occluder was insufficiently hooked to the pectinate muscle after deployment and the occluder was displaced after traction; H: the red pattern represents the occluder; landing zone planning of external orifice under traditional method. Due to the axial direction and depth, the occluder had more exposed shoulders, unstable intraoperative traction, and failure of release. (I-N): I and J referring to the red line area where the distal end of the occluder was insufficiently hooked to the pectinate muscle after deployment and the occluder was displaced after traction; L and M: the red pattern represents the occluder; landing area planning of internal orifice following the axial direction of main lobe. The occluder was stably released. VR, volume rendering; LAA, left atrial appendage; MIP, maximal intensity projection; MPR, multiplanar cardiac reformat.

Table 1 The measurements of the traditional method and the new method and the actual value

Parameters	Traditional method	New method	Actual value
The longest diameter (mm), average	27.97 (23.73, 29.96)[ab]	25.11±3.61[c]	24.5 (21.0, 26.0)
The depth (mm), average	26.25 (22.05, 29.39)[ab]	24.33±4.38	24.0 (22.0, 27.0)
The average diameter (mm), average	25.86 (22.05, 27.41)[a]	23.73 (20.99, 25.43)	–
The perimeter (mm), average	78.85±12.35[a]	74.80±11.07	–

Data are presented as M (1/4, 3/4) and mean ± SD. Compared with new method, [a], P<0.05; compared with actual value, [b], P<0.05; the measurements of new method compared with actual value, [c], P<0.05. SD, standard deviation.

Table 2 Comparison of error between measured value by two methods and the actual value

Comparison of error	Longest diameter measure			Depth measure		
	Traditional method	New method	P value	Traditional method	New method	P value
The mean error from the actual value (mm), average	2.90±2.83	0.9 (–0.13, 2.50)	<0.001	1.40±3.45	0.10 (–1.33, 1.95)	<0.001
The mean absolute value from the actual value (mm), average	2.71 (1.17, 4.38)	1.4 (0.40, 2.53)	<0.001	2.36 (0.74, 4.58)	1.55 (0.60, 3.10)	0.02

Data are presented as M (1/4, 3/4) and mean ± SD. SD, standard deviation.

Correlation between measurements under CCTA and occluder size

A strong correlation was discovered between the longest diameter measured by the traditional method and occluder size (r=0.770, P<0.001), as well as a strong correlation between the occluder size and the average diameter and perimeter measured by the traditional method and the longest diameter, average diameter, and perimeter measured by the new method (r=0.803, P<0.001; r=0.877, P<0.001; r=0.826, P<0.001; r=0.849, P<0.001, r=0.919, P<0.001). The correlation between the measurements of the new method and the occluder size was stronger than that between the measurements of traditional method and the occluder size. Notably, the perimeter has the strongest correlation with the occluder size (*Figure 3*).

Discussion

TEE remains an important means of preoperative evaluation, intraoperative monitoring, and postoperative follow-up of LAAC. With its higher spatial resolution than TEE, CCTA can utilize MPR, VR, MIP, and other techniques to reconstruct 3-dimensional (3D) images of LAA as well as to display the spatial structure and the relationship with adjacent tissues of LAA from all angles, which has been gradually recognized by the public for planning the landing zone of LAAC (7-9). Moreover, the operator can perform adequate preoperative assessment of the LAA, reasonably plan the landing zone, and estimate the occluder type, size, and axial direction after implantation using those techniques. Previous studies have shown that CCTA is more accurate than TEE in planning landing zone (10-13). Numerous studies and expert consensus define the LAA landing zone under CCTA as the line connecting 1–2 cm inside Coumadin ridge to the left superior PV and the left circumflex coronary artery, and its depth as the distance from the midpoint of the landing zone diameter to the distal tip of the LAA (14-16). The definition of the landing zone by CCTA is based on the that by TEE. The advantage of CCTA lies in the unification of the criteria, resulting in less impact by the subjective factors of the operator and basic satisfaction of the preoperative planning of LAA with regular morphology; in terms of its disadvantages, the actual landing zones of a significant proportion of patients are not the traditional planning landing zone of CCTA (*Figure 1,2*) because the selection of the landing zone during the actual operation is affected by the axial direction, size, shape and pectinate muscle distribution of the atrial appendage, resulting in a large deviation in the relevant data measured and impact of the occluder selection. The new method makes use of the VR technology to display the 3D morphology of LAA and

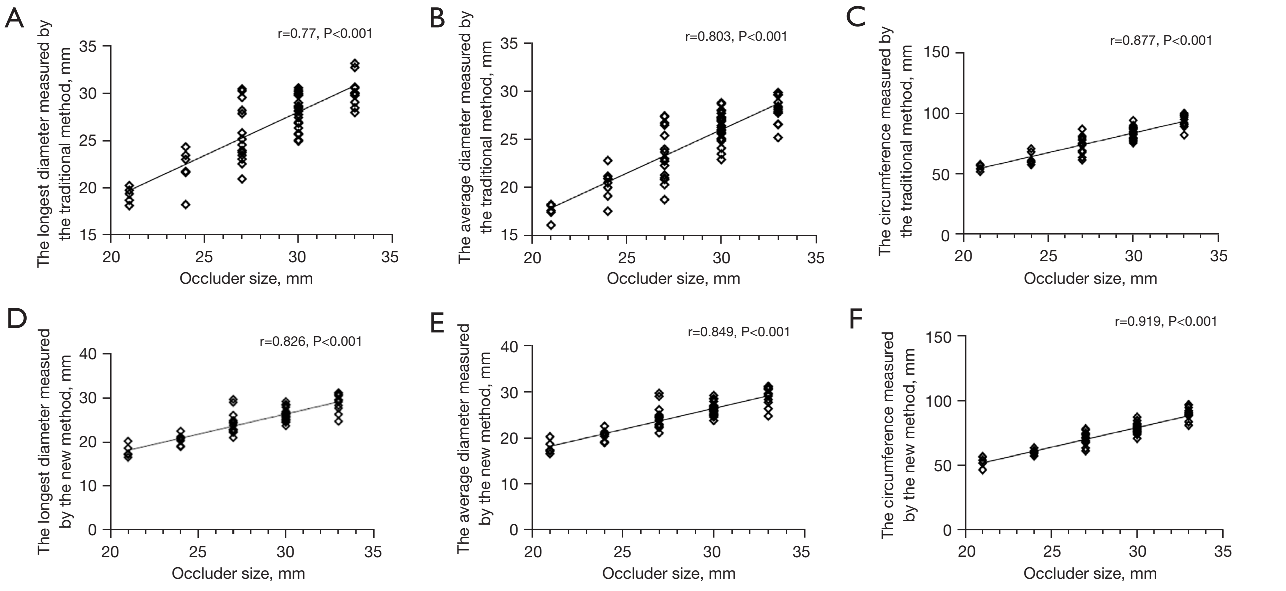

Figure 3 Correlation between measurements under CCTA and occluder size. CCTA, cardiac computed tomography angiography.

determine its maximum expansion angle. Combined with the principles of stability, safety, and adequate closure, the landing area planned by the new method can be closer to the actual surgical process at the that angle. The following patients were not included in this study: those with intraoperative cardiac tamponade, DRT, residual shunt ≥5 mm in the occluder, occluder displacement or ischemic stroke at CCTA or TEE follow-up 3 months after surgery. To maintain the LAAC in its optimal state, external variables were minimized. Accurate positioning of the landing zone can reduce the error of its parameter measurement. Using the new method, the error between the measured diameter and depth of landing zone and the actual intraoperative measurement value is the smallest. The correlation between the longest diameter, average diameter of the landing zone measured by the new method, and the occluder size was stronger than that of the traditional method, and even stronger than that of the traditional method of the same kind (17,18).

The new method also presented the strongest correlation between the landing zone perimeter and occluder size. Most research centers in China select the occluder size on the basis of the longest diameter of the landing zone. However, the ostium morphology of LAA varies greatly, and it may be generically classified into oval, round, triangle, foot, and water drop types, with the oval type accounting for the majority (19). For patients with flat oval type whose longest diameter significantly exceeds the shortest diameter, selecting the Watchman occluder device with proximal round shape simply according to the longest diameter may result in the selection of too large occluder and the risk of LAA tear. It has been demonstrated that the landing zone perimeter can better predict the optimal occluder size because the length diameter and short diameter of landing zone ostium will change and the ostium will change to a circular shape after occluder implantation, whereas the perimeter often remains unchanged (20-22). However, in the aforementioned studies, the landing zone was located using the conventional method, which has the drawback of providing an erroneous assessment of the landing zone. As such, this study further confirms that landing zone perimeter has the strongest correlation with occluder size using more accurate landing zone data and thus landing zone perimeter can be used as an important occluder size prediction parameter.

There were still some limitations to this study. The individualized planning landing zone under CCTA is greatly influenced by operator subjective factors, which may have some bearing on the results. Furthermore, this was a single-center retrospective study with a small sample size. Therefore, the wide application of this method requires further evaluation of multi-center clinical studies with larger sample size.

Conclusions

Collectively, individualized planning of the landing zone under CCTA is more accurate than the traditional method. It is especially important to select the occluder size for patients with flat oval ostium of the landing zone, and the landing zone perimeter measured by the new method is most strongly correlated with the occluder size.

Acknowledgments

Funding: This work was supported by Jiangsu 333 High level Talent Research Project (No. BRA2020193).

Footnote

Reporting Checklist: The authors have completed the STROBE reporting checklist. Available at https://atm.amegroups.com/article/view/10.21037/atm-22-6183/rc

Data Sharing Statement: Available at https://atm.amegroups.com/article/view/10.21037/atm-22-6183/dss

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://atm.amegroups.com/article/view/10.21037/atm-22-6183/coif). The authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by ethics board of The Affiliated Taizhou People's Hospital of Nanjing Medical University (No. KY-2021-080-01) and informed consent was taken from all the patients.

References

1. Kirchhof P, Benussi S, Kotecha D, et al. 2016 ESC Guidelines for the management of atrial fibrillation developed in collaboration with EACTS. Europace 2016;18:1609-78.
2. Johnson WD, Ganjoo AK, Stone CD, et al. The left atrial appendage: our most lethal human attachment! Surgical implications. Eur J Cardiothorac Surg 2000;17:718-22.
3. Hsu JC, Maddox TM, Kennedy KF, et al. Oral Anticoagulant Therapy Prescription in Patients With Atrial Fibrillation Across the Spectrum of Stroke Risk: Insights From the NCDR PINNACLE Registry. JAMA Cardiol 2016;1:55-62.
4. Camm AJ, Lip GY, De Caterina R, et al. 2012 focused update of the ESC Guidelines for the management of atrial fibrillation: an update of the 2010 ESC Guidelines for the management of atrial fibrillation--developed with the special contribution of the European Heart Rhythm Association. Europace 2012;14:1385-413.
5. Ruan ZB, Wang F, Chen GC, et al. A Comparative Study of Three Imaging Modalities for Size Selection of a Watchman Left Atrial Appendage Closure Device. Yonsei Med J 2022;63:325-32.
6. Schmidt-Salzmann M, Meincke F, Kreidel F, et al. Improved Algorithm for Ostium Size Assessment in Watchman Left Atrial Appendage Occlusion Using Three-Dimensional Echocardiography. J Invasive Cardiol 2017;29:232-8.
7. Morcos R, Megaly M, Saad M, et al. In-hospital outcomes of transesophageal versus intracardiac echocardiography guided left atrial appendage closure. Catheter Cardiovasc Interv 2022;99:1572-81.
8. Behnes M, Akin I, Sartorius B, et al. --LAA Occluder View for post-implantation Evaluation (LOVE)--standardized imaging proposal evaluating implanted left atrial appendage occlusion devices by cardiac computed tomography. BMC Med Imaging 2016;16:25.
9. Dieker W, Behnes M, Fastner C, et al. Impact of left atrial appendage morphology on thrombus formation after successful left atrial appendage occlusion: Assessment with cardiac-computed-tomography. Sci Rep 2018;8:1670.
10. Reeves RA, Halpern EJ, Rao VM. Cardiac Imaging Trends from 2010 to 2019 in the Medicare Population. Radiol Cardiothorac Imaging 2021;3:e210156.
11. Mosleh W, Sheikh A, Said Z, et al. The use of cardiac-CT alone to exclude left atrial thrombus before atrial

fibrillation ablation: Efficiency, safety, and cost analysis. Pacing Clin Electrophysiol 2018;41:727-33.
12. Obasare E, Mainigi SK, Morris DL, et al. CT based 3D printing is superior to transesophageal echocardiography for pre-procedure planning in left atrial appendage device closure. Int J Cardiovasc Imaging 2018;34:821-31.
13. Gilhofer TS, Abdellatif W, Nicolaou S, et al. Cardiac CT angiography after percutaneous left atrial appendage closure: early versus delayed scanning after contrast administration. Diagn Interv Radiol 2021;27:703-9.
14. Korsholm K, Berti S, Iriart X, et al. Expert Recommendations on Cardiac Computed Tomography for Planning Transcatheter Left Atrial Appendage Occlusion. JACC Cardiovasc Interv 2020;13:277-92.
15. Zhang T, Chu HM, Chen LB, et al. Clinical value of plane computed tomography and three-dimensional segmented CT reconstruction for the guidance of left atrial appendage closure: a comparative study of Watchman device selection. Chinese Journal of Cardiac Arrhythmias 2017;21:371-5.
16. Liu G, Chen T, Mu Y, et al. Value of Three Imaging Modalities for the Size Selection of Left Atrial Appendage Closure Device. Medical Journal of Peking Union Medical College Hospital 2020;11:21-6.
17. Ren JL, Wang XC, Zhong CH, et al. Comparing value of transesophageal echocardiography, dual-source CT and left atrial appendage angiography in selection of left atrial appendage occluder size. Chinese Journal of Cardiac Arrhythmias 2019;23:430-5.
18. Wang X, Hou ZH, An YQ, et al. Correlation between Left Atrial Appendage (LAA) Parameters Measured by CT Angiography and the Size of Watchman Occluder Selected in LAA Occlusion. Molecular Cardiology of China 2019;19:3039-43.
19. Wang Y, Di Biase L, Horton RP, et al. Left atrial appendage studied by computed tomography to help planning for appendage closure device placement. J Cardiovasc Electrophysiol 2010;21:973-82.
20. Goitein O, Fink N, Hay I, et al. Cardiac CT Angiography (CCTA) predicts left atrial appendage occluder device size and procedure outcome. Int J Cardiovasc Imaging 2017;33:739-47.
21. Cho I, Kim WD, Lee OH, et al. Pre-procedural determination of device size in left atrial appendage occlusion using three-dimensional cardiac computed tomography. Sci Rep 2021;11:24107.
22. Kong D, Jiang Y, Zhang X, et al. Reference value of perimeter-derived diameter assessed by three-dimensional transesophageal echocardiography in left atrial appendage occluder size selection. Echocardiography 2020;37:1828-37.

Cite this article as: Li W, Zhang J, Ruan Z, Zhao J, Zhang B, Zhang J. The effect of two different methods of planning landing zone for left atrial appendage closure by cardiac computed tomography angiography: a comparative study. Ann Transl Med 2023;11(2):75. doi: 10.21037/atm-22-6183