Clinical Radiology xxx (2018) 1–10

Contents lists available at ScienceDirect

Clinical Radiology

journal homepage: www.clinicalradiologyonline.net

Left atrial appendage morphology and relative contrast agent concentration in patients undergoing coronary artery CTA

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ARTICLE INFORMATION

Article history:
Received 4 February 2018
Accepted 8 June 2018

AIM: To evaluate whether certain morphological features of the left atrial appendage (LAA) would influence the LAA/ascending aorta (AA) radiodensity ratio, as a reflection of the blood flow conditions in the LAA.

MATERIALS AND METHODS: Eight-hundred and eight consecutive patients undergoing computed tomography angiography (CCTA) were evaluated. Of these, 749 had no history of atrial fibrillation and none had suffered acute stroke. The LAA/AA radiodensity ratio, and the length, lobe number, and morphological classification of LAAs were assessed.

RESULTS: The distribution of morphological classes for LAAs were: windsock 62.3%, cactus 18.6%, chicken wing 10.0%, and cauliflower 9.2%. The mean LAA/AA radiodensity ratio was 0.87±0.14 (range 0.22–1.44). Female gender (p=0.001), elevated body mass index (BMI; r=−0.129; p=0.003), and diabetes (p=0.03) were associated with lower LAA/AA radiodensity ratios, while heart failure (p=0.017), significant coronary artery stenosis (p=0.010), and LAAs with multiple lobes (p=0.018), exhibited higher LAA/AA radiodensity ratios. Multiple regression analysis revealed that a short one-lobed cauliflower morphology was an independent predictor (p=0.007) of a decreased LAA/AA radiodensity ratio.

CONCLUSION: A decline in the LAA/AA radiodensity ratio may reflect decreased blood flow in the LAA, paralleling spontaneous echo contrast in transoesophageal echocardiography. Thus, CCTA might be of value in recognising LAA structures that predispose to decreased blood flow.

Introduction

Stroke is a major cause of death and long-term disability.[1] Almost 90% of strokes have an ischaemic aetiology, with approximately one-fifth of thromboembolic events provoked by thrombus formation in the heart.[2]

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https://doi.org/10.1016/j.crad.2018.06.012
0009-9260/

Most cardioembolic stroke patients suffer from atrial fibrillation (AF),[3] which predisposes to clot generation in the left atrium (LA) and left atrial appendage (LAA).[4] Critically, in >90% of cardioembolic incidents, the thrombus originates from the LAA.[4] Certain LAA morphologies appear to correlate with a decreased LAA flow velocity (LAAFV), especially in patients with AF,[5,6] and most of the previous studies have demonstrated an association between LAA morphological features and risk for stroke.[7–9]

Transoesophageal echocardiography (TOE) is considered the reference standard for recognising LAA thrombi.[2] Significant TOE findings include the demonstration of LAA thrombus and dense non-clearing spontaneous echocardiographic contrast (SEC), both of which predict fatal and non-fatal thromboembolic events[10,11]; however, computed tomography (CT) offers a non-invasive option with which to analyse thrombi in the LAA with an acceptable sensitivity and specificity[2] (Table 1). Blood flow in the LAA can be analysed indirectly in CT by calculating the radiodensity ratio, obtained by dividing the radiodensity value for the LAA with the corresponding value for the ascending aorta (AA). The LAA/AA radiodensity ratio usefully allows the clinician to distinguish blood stasis from a thrombus.[12–14]

The aim of the present study was to evaluate whether certain morphological features of the LAA would influence the LAA/AA radiodensity ratio, as a reflection of the blood flow conditions in the LAA. The majority of previous studies investigating the LAA/AA radiodensity ratio have concentrated on patients with AF (Table 1); however, for reference purposes, it is important to elucidate the factors that influence blood flow in the LAA of patients without AF. Thus, the LAA/AA radiodensity ratios in consecutive patients who underwent coronary artery CT angiography (CCTA) were analysed at the mid-diastolic phase, who were in sinus rhythm, with no signs of LAA thrombi.

Materials and methods

Population

The overall study population comprised 816 consecutive patients admitted to Kuopio University Hospital for CCTA imaging between October 2009 and July 2015. CCTA was scheduled to rule out coronary artery disease (CAD) in patients with a low-to-moderate pretest probability for CAD, and to screen for the aetiology of heart failure and coronary anomalies. Altogether, 808 patients formed the final study group after three patients were excluded for being aged <18 years, with a further three excluded because their LAAs could not be reliably assessed. Two patients were also excluded for AF during CCTA.

All clinical investigations were conducted according to the principles of the Declaration of Helsinki. Kuopio University Hospital's Research Ethics Board approved the study. The Chair of the Hospital District waived the need for written informed consent for these retrospective analyses.

Table 1
Overview of studies that present cut-off values for LAA/AA radiodensity ratios.

Author (year of publication)	Imaging technique	Contrast agent initiation	Test bolus or bolus tracking	Indication	*N*, study group (%, AF patients)	Cut-off value for LAA/AA radiodensity ratio	Clinical implication of cut-off value	Sensitivity, and specificity for cut-off value
Taina *et al.* (2016)[15]	16-row cCT + TOE	Arterial and venous phase	BT	Acute stroke/TIA	102 (100%)	0.245	Detection of LAA thrombus	100%, 100%
Budoff *et al.* (2014)[16]	64-row CCTA + TOE	Venous phase	BT	PVI	84 (100%)	0.242	Detection of LAA thrombus	84%, 88%
Choi *et al.* (2013)[17]	Two-phase dual source CT + TOE	Arterial phase	BT	Mitral valve surgery and Maze operation	106 (100%)	0.5	Detection of LAA thrombus	96%, 90%
Hur *et al.* (2013)[12]	Dual-enhancement single-phase cCT + TOE	Venous phase	TB	Radiofrequency catheter ablation	101 (100%)	0.24	Distinguishing LAA thrombus from circulatory stasis	89%, 100%
Hur *et al.* (2012)[13]	64-row MDCT + TOE	Venous phase	TB	Recent stroke	32 (100%)	0.19	Distinguishing LAA thrombus from circulatory stasis	82%, 67%
Hur *et al.* (2011)[14]	Dual-source CT + TOE	Venous phase	TB	Recent stroke	83 (34%)	0.2	Distinguishing LAA thrombus from circulatory stasis	80%, 85%
Kim SC *et al.* (2010)[18]	64-row MDCT + TOE	Arterial phase and late-phase	BT	Acute stroke	314 (23%)	0.5	Distinguishing LAA thrombus from SEC	100%,100%
Singh *et al.* (2009)[19]	64-row MDCT + TOE	Arterial phase	BT	PVI	51 (100%)	0.78	Predictor of thrombus with TOE	100%,87.8%
Patel *et al.* (2008)[20]	64-row MDCT + TOE	Venous phase (triple phase)	TB	PVI	72 (95%)	0.75	Predictor of LAA thrombus or dense non-clearing SEC on TOE	100%, 72.2%
Kim YY *et al.* (2007)[21]	16/64-row MDCT + TOE	Venous phase	BT	PVI	223 (100%)	0.25	Distinguishing LAA thrombus from SEC	30%, 96%

AA, ascending aorta; LAA, left atrial appendage; BT, bolus tracking; CT, computed tomography; cCT, cardiac CT; MDCT, Multidetector CT; PVI, pulmonary vein isolation; SEC, spontaneous echo contrast; TB, test bolus; TOE, transoesophageal echocardiography; TIA, transient ischaemic attack.

Please cite this article in press as: Korhonen M, et al., Left atrial appendage morphology and relative contrast agent concentration in patients undergoing coronary artery CTA, Clinical Radiology (2018), https://doi.org/10.1016/j.crad.2018.06.012