

Supplementary material

Li L, You C, Yang J, et al. Normal values of left atrial size and strain analyzed by dedicated speckle-tracking echocardiography in the Chinese population. Kardiol Pol. 2023.

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Table S1. Clinical and LV characteristics of the healthy population

	Healthy subjects(N=111)
Clinical characteristics	
Age,y	48(13)
Male gender,%	51(46)
Height,cm	164(8)
Weight,kg	64(10)
BSA,m ²	1.67(0.16)
Systolic BP,mmHg	119(11)
Diastolic BP, mmHg	75(8)
Heart rate, beats/min	68(10)
Left ventricular characteristics	
LV ejection fraction,%	60(5)
LV end-diastolic diameter,mm	45.4(3.8)
LV end-systolic diameter, mm	28.2(3.4)
Interventricular septum,mm	7.7(1.0)
LV posterior wall,mm	7.6(0.9)
LV mass index,g/m ²	83.4(21.9)
Septal early-diastolic mitral annular velocity(e') by TDI,cm/s	9.0(2.3)
Lateral early-diastolic mitral annular velocity(e') by TDI, cm/s	12.3(4.5)
Mitral early-diastolic inflow velocity(E),cm/s	74.9(16.4)
Mitral late-diastolic inflow velocity(A),cm/s	62.4(13.0)
Mitral E/e' septal-lateral ratio	7.3(1.8)
Mitral E/A ratio	1.2(0.3)
Deceleration time,ms	205(61)
Global longitudinal strain,%	20.4(2.6)
Peak systolic dispersion,ms	36(10)

Data are expressed as mean(SD)or percentages

Abbreviations: LV, left ventricle; BSA, body surface area; SD, standard deviation; TDI, tissue Doppler imaging

Table S2. LA volumetric parameters by sex

	All subjects	Men	Women	P-value
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	(N=111)	(N=51)	(N=60)	(men vs. women)
Maximum LAVi, mL/m ² (2Ch)	24.4(7.0)	24.5(6.9)	24.3(7.1)	0,91
Minimum LAVi, mL/m ² (2Ch)	9.8(4.1)	9.4(3.5)	10.1(4.5)	0,39
LA pre-A volume index, mL/m ² (2Ch)	17.9(5.7)	18.1(5.2)	17.8(6.2)	0,83
Maximum LAVi, mL/m ² (4Ch)	21.7(5.6)	21.4(5.9)	21.9(5.3)	0,63
Minimum LAVi, mL/m ² (4Ch)	8.7(3.2)	8.7(3.2)	8.7(3.2)	0,88
LA pre-A volume index, mL/m ² (4Ch)	14.1(4.4)	14.4(4.6)	13.7(4.3)	0,42
Maximum LAVi, mL/m ² (BIP)	23.4(5.6)	23.3(6.0)	23.5(5.3)	0,83
Minimum LAVi, mL/m ² (BIP)	9.2(3.4)	9.0(3.1)	9.4(3.6)	0,55
LA pre-A volume index, mL/m ² (BIP)	16.1(4.7)	16.2(4.7)	15.9(4.7)	0,70

Data are expressed as mean(SD)

Abbreviations: LAVI, left atrial volume index; SD, standard deviation; 2Ch, 2-chamber view, 4Ch, 4-chamber view; BIP, biplane LA volumetric values were calculated as the averaged values from the 2Ch and 4Ch views

Table S3. Limits of normality for LA volumetric parameters

	All subjects LLN- ULN(N=111)	Men LLN- ULN(N=51)	Women LLN- ULN(N=60)
Maximum LAVi, mL/m ² (2Ch)	10.6-38.1	10.9-38.0	10.3-38.2
Minimum LAVi, mL/m ² (2Ch)	1.7-17.8	2.5-16.2	1.2-18.9
LA pre-A volume index, mL/m ² (2Ch)	6.7-29.0	7.9-28.2	5.6-29.9
Maximum LAVi, mL/m ² (4Ch)	10.7-32.6	9.8-32.9	11.5-32.2
Minimum LAVi, mL/m ² (4Ch)	2.4-14.9	2.4-14.9	2.4-14.9
LA pre-A volume index, mL/m ² (4Ch)	5.4-22.7	5.3-23.4	5.2-22.1
Maximum LAVi, mL/m ² (BIP)	12.4-34.3	11.5-35.0	13.1-33.8
Minimum LAVi, mL/m ² (BIP)	2.5-15.8	2.9-15.0	2.3-16.4
LA pre-A volume index, mL/m ² (BIP)	6.8-25.3	6.9-25.4	6.6-25.1

Abbreviations: LLN, lower limit of normality; ULN, upper limit of normality; see Table S2

Table S4. LA functional parameters by sex

	All subjects (N=111)	Men (N=51)	Women (N=60)	P-value (men vs. women)
LA reservoir strain,%(2Ch)	34.0(7.1)	33.7(6.7)	34.2(7.5)	0,72
LA conduit strain,%(2Ch)	17.8(6.1)	17.4(5.4)	18.1(6.7)	0,55
LA booster strain,%(2Ch)	16.1(4.5)	16.3(4.5)	16.0(4.5)	0,72
LA emptying volume, mL(2Ch)	24.5(7.4)	26.6(8.1)	22.7(6.4)	0,005

LA emptying volume index, mL/m ² (2Ch)	14.6(4.1)	15.1(4.5)	14.2(3.7)	0,29
LA ejection fraction (2Ch),%	60.4(8.7)	61.6(8.1)	59.5(9.1)	0,19
LA reservoir strain,%(4Ch)	31.5(6.8)	31.8(6.7)	31.3(6.9)	0,74
LA conduit strain,%(4Ch)	18.5(6.6)	18.1(6.4)	18.9(6.9)	0,56
LA booster strain,%(4Ch)	12.6(4.4)	13.6(3.8)	11.9(4.8)	0,046
LA emptying volume, mL(4Ch)	21.7(6.4)	22.4(7.0)	21.1(5.8)	0,26
LA emptying volume index, mL/m ² (4Ch)	12.9(3.5)	12.6(3.7)	13.2(3.3)	0,39
LA ejection fraction (4Ch)	60.0(8.6)	59.3(8.1)	60.6(9.1)	0,44
LA reservoir strain,%(BIP)	32.7(6.3)	32.7(6.0)	32.7(6.6)	0,99
LA conduit strain,%(BIP)	18.1(6.0)	17.7(5.4)	18.4(6.4)	0,54
LA booster strain,%(BIP)	14.5(3.6)	14.9(3.6)	14.2(3.5)	0,34
LA emptying volume, mL(BIP)	23.7(6.3)	25.2(7.2)	22.5(5.3)	0,03
LA emptying volume index, mL/m ² (BIP)	14.1(3.4)	14.2(3.9)	14.1(3.0)	0,88
LA ejection fraction,%(BIP)	61.0(7.9)	61.4(6.9)	60.7(8.7)	0,64

Data are expressed as mean(SD)

Abbreviations: see Table S2

Table S5. Limits of normality for LA functional parameters

	All subjects	Men	Women
	LLN-ULN	LLN-ULN	LLN-ULN
LA reservoir strain,%(2Ch)	20.0-47.9	20.5-46.8	19.5-48.9
LA conduit strain,%(2Ch)	5.8-29.7	6.8-27.9	4.9-31.2
LA booster strain,%(2Ch)	7.2-24.9	7.4-25.1	7.1-24.8
LA emptying volume, mL(2Ch)	9.9-39.0	10.7-42.4	10.1-35.2
LA emptying volume index, mL/m ² (2Ch)	6.5-22.6	6.2-23.9	6.9-21.4
LA ejection fraction (2Ch),%	43.3-77.4	45.7-77.4	41.6-77.3
LA reservoir strain,%(4Ch)	18.1-44.8	18.6-44.9	17.7-44.8
LA conduit strain,%(4Ch)	5.5-31.4	5.5-30.6	5.3-32.4
LA booster strain,%(4Ch)	3.9-21.2	6.1-21.0	2.4-21.3
LA emptying volume, mL(4Ch)	9.1-34.2	8.6-36.1	9.7-32.4
LA emptying volume index, mL/m ² (4Ch)	6.0-19.7	5.3-19.8	6.7-19.6
LA ejection fraction (4Ch)	43.1-76.8	43.4-75.1	42.7-78.4
LA reservoir strain,%(BIP)	20.3-45.0	20.9-44.4	19.7-45.6
LA conduit strain,%(BIP)	6.3-29.8	7.11-28.2	5.8-30.9
LA booster strain,%(BIP)	7.4-21.5	7.84-21.9	7.3-21.0
LA emptying volume, mL(BIP)	11.3-36.0	11.0-39.3	12.1-32.8
LA emptying volume index, mL/m ² (BIP)	7.4-20.7	6.5-21.8	8.2-19.9
LA ejection fraction,%(BIP)	45.5-76.4	47.8-74.9	43.6-77.7

Abbreviations: see Table S2 and Table S3

Table S6. LA volumetric parameters by age quartile

	Quartile1	Quartile2	Quartile3	Quartile4	P-value
	(N=30)	(N=26)	(N=29)	(N=26)	

Maximum LAVi, mL/m ² (2Ch)	22.5(6.5)	25.6(6.6)	22.91(5.6)	27.0(8.4)	0,046
Minimum LAVi, mL/m ² (2Ch)	8.2(3.4)	9.7(2.2)	9.6(4.3)	11.9(5.2)*	0,008
LA pre-A volume index, mL/m ² (2Ch)	15.2(5.2)	18.6(4.5)	17.4(5.4)	21.0(6.4)*,&	0,001
Maximum LAVi, mL/m ² (4Ch)	20.5(4.6)	22.7(6.8)	21.2(5.2)	22.7(5.5)	0,34
Minimum LAVi, mL/m ² (4Ch)	7.2(2.2)	8.7(3.0)	8.9(2.9)	10.1(3.9)*	0,007
LA pre-A volume index, mL/m ² (4Ch)	11.3(2.9)	14.5(4.8)*	14.6(3.9)*	16.2(4.8)*	0,0003
Maximum LAVi, mL/m ² (BIP)	21.8(4.6)	24.0(5.6)	22.5(4.9)	25.1(6.6)	0,11
Minimum LAVi, mL/m ² (BIP)	7.6(2.4)	9.2(2.3)	9.1(3.2)	11.2(4.5)*	0,001
LA pre-A volume index, mL/m ² (BIP)	13.1(3.4)	16.6(4.2)*	16.1(4.1)*	18.7(5.3)*	<.0001

Data are expressed as mean(SD).

Abbreviations: Q1,Quartile1(18-39 years old); Q2,Quartile 2(40-52 years old); Q3,Quartile 3(53-58 years old); Q4,Quartile 4(59-85 years old); seeTable S2

*p < 0.05 versus the Q1 group; # p < 0.05 versus the Q2 group; &: p < 0.05 versus the Q3 group

Table S7. LA functional parameters by age quartile

	Quartile1 (N=30)	Quartile2 (N=26)	Quartile3 (N=29)	Quartile4 (N=26)	P-value
LA reservoir strain,%(2Ch)	38.6(7.3)	35.2(4.9)	31.9(6.8)*	29.7(5.9)*,#	<.0001
LA conduit strain,%(2Ch)	23.2(6.0)	18.1(5.6)*	15.5(4.2)*	13.8(3.9)*,#	<.0001
LA booster strain,%(2Ch)	15.3(4.1)	17.0(3.7)	16.4(5.3)	16.0(4.7)	0,57
LA emptying volume, mL(2Ch)	24.5(7.9)	27.3(9.1)	22.5(5.1)	23.8(6.8)	0,11
LA emptying volume index, mL/m ² (2Ch)	14.3(4.1)	15.9(5.0)	13.4(2.6)	14.9(4.3)	0,14
LA ejection fraction (2Ch),%	63.8(8.4)	61.4(4.9)	59.6(10.1)	56.6(8.9)*	0,01
LA reservoir strain,%(4Ch)	36.3(6.6)	32.3(6.6)*	29.6(5.2)*	27.4(5.4)*,#	<.0001
LA conduit strain,%(4Ch)	24.5(6.1)	19.1(6.9)*	15.8(3.6)*,#	14.1(4.1)*,#	<.0001
LA booster strain,%(4Ch)	11.8(4.0)	13.0(3.0)	13.7(4.1)	12.1(6.1)	0,33
LA emptying volume, mL(4Ch)	22.2(5.9)	24.1(8.2)	20.6(6.1)	19.8(4.3)	0,07
LA emptying volume index, mL/m ² (4Ch)	13.1(3.4)	13.9(4.3)	12.3(3.4)	12.5(2.9)	0,31
LA ejection fraction (4Ch)	64.1(8.0)	61.4(6.5)	58.0(8.7)*	56.1(9.2)*,#	0,001
LA reservoir strain,%(BIP)	37.4(6.0)	33.8(5.6)*	30.8(5.3)*,#	28.5(4.6)*,#	<.0001
LA conduit strain,%(BIP)	23.8(5.3)	18.7(5.9)*	15.6(3.5)*,#	13.8(3.4)*,#	<.0001
LA booster strain,%(BIP)	13.7(3.6)	14.9(3.1)	15.1(4.1)	14.6(3.3)	0,43
LA emptying volume, mL(BIP)	24.1(6.0)	26.5(8.1)	22.2(5.3)	22.2(5.0)	0,043
LA emptying volume index, mL/m ² (BIP)	14.1(3.1)	15.4(4.2)	13.2(2.7)	14.0(3.2)	0,14
LA ejection fraction,%(BIP)	65.2(7.2)	62.3(5.0)	59.7(8.2)*	56.5(8.1)*,#	0,0002

Data are expressed as mean(SD).

Abbreviations: see Table S2 and S6

*p < 0.05 versus the Q1 group; # p < 0.05 versus the Q2 group; &: p < 0.05 versus the Q3 group

Table S8. Correlations of LA strain with different variables

Variables	LA reservoir strain		LA conduit strain		LA booster strain	
	r	P	r	P	r	P
Apical 2-chamber view						
Age, years	-0.5044	< .0001	-0.6081	< .0001	0,0381	0,69
LV global longitudinal strain, %	0,2366	0,01	0,2684	0,004	0,0035	0,97
LV peak systolic dispersion, ms	-0,2822	0,002	-0.3078	0,001	-0,0156	0,87
Maximum LAVi, mL/m ²	-0,2272	0,01	-0.0987	0,30	-0,2324	0,01
LA ejection fraction, %	0,7222	< .0001	0,5866	< .0001	0,3438	0,0002
Apical 4-chamber view						
Age, years	-0.4855	< .0001	-0.6131	< .0001	0,1151	0,22
LV global longitudinal strain, %	0,2672	0,004	0,2959	0,001	-0,0636	0,51
LV peak systolic dispersion, ms	-0,2435	0,01	-0,2664	0,004	0,0661	0,49
Maximum LAVi, mL/m ²	-0,1667	0,07	-0,0566	0,55	-0,1842	0,05
LA ejection fraction, %	0,6773	< .0001	0,6263	< .0001	0,1582	0,09
Apical biplane views						
Age, years	-0.5441	< .0001	-0.6514	< .0001	0,1240	0,19
LV global longitudinal strain, %	0,2762	0,003	0,3038	0,001	-0,0006	0,99
LV peak systolic dispersion, ms	-0,2905	0,002	-0,3040	0,001	-0,0166	0,86
Maximum LAVi, mL/m ²	-0,2225	0,01	-0,0974	0,31	-0,2413	0,01
LA ejection fraction, %	0,7178	< .0001	0,6388	< .0001	0,2321	0,01

Table S9. Parameters associated with LA reservoir strain

Variables	Simple linear regression			Multivariable linear regression		
	β	SE	P	β	SE	P
Apical 2-chamber view						
Age, years	-0,2674	0,0433	<.0001	-0,1640	0,0318	<.0001
LV global longitudinal strain, %	0,6515	0,2562	0,01	0,5653	0,1586	<.0001
LV peak systolic dispersion, ms	-0,1995	0,0649	0,002			
Maximum LAVi, mL/m ²	-0,2322	0,0953	0,01			
LA ejection fraction, %	0,5937	0,0545	<.0001	0,5013	0,0500	<.001
Apical 4-chamber view						
Age, years	-0,2434	0,0420	<.0001	-0,1324	0,0365	<.001
LV global longitudinal strain, %	0,6997	0,2425	0,004	0,3238	0,1868	0,08
LV peak systolic dispersion, ms	-0,1647	0,0628	0,01	-0,0727	0,0488	0,14

Maximum LAVi, mL/m ²	-0,2041	0,1155	0,07			
LA ejection fraction, %	0,5349	0,0556	<.0001	0,4388	0,0561	<.0001
Apical biplane views						
Age, years	-0,2536	0,0375	<.0001	-0,1490	0,0299	<.0001
LV global longitudinal strain, %	0,6764	0,2254	0,003	0,5185	0,1445	0,001
LV peak systolic dispersion, ms	-0,1827	0,0576	0,002			
Maximum LAVi, mL/m ²	-0,2554	0,1072	0,01			
LA ejection fraction, %	0,5779	0,0537	<.0001	0,4521	0,0520	<.0001

Abbreviations: SE, standard error

Table S10. Parameters associated with LA conduit strain

Variables	Simple linear regression			Multivariable linear regression		
	β	SE	P	β	SE	P
Apical 2-chamber view						
Age, years	-0,2740	0,0343	<.0001	-0,2157	0,0290	<.0001
LV global longitudinal strain, %	0,6357	0,2185	0,004	0,5957	0,1444	<.0001
LV peak systolic dispersion, ms	-0,1872	0,0554	0,001			
Maximum LAVi, mL/m ²	-0,0868	0,0838	0,30			
LA ejection fraction, %	0,4148	0,0549	<.0001	0,2958	0,0455	<.0001
Apical 4-chamber view						
Age, years	-0,2988	0,0369	<.0001	-0,2294	0,0314	<.0001
LV global longitudinal strain, %	0,7492	0,2338	0,001	0,5568	0,1572	0,001
LV peak systolic dispersion, ms	-0,1751	0,0607	0,004			
Maximum LAVi, mL/m ²	-0,0673	0,1137	0,55			
LA ejection fraction, %	0,4808	0,0573	<.0001	0,3207	0,0504	<.0001
Apical biplane views						
Age, years	-0,2869	0,0320	<.0001	-0,2161	0,0273	<.0001
LV global longitudinal strain, %	0,7032	0,2112	0,001	0,6055	0,1320	<.0001
LV peak systolic dispersion, ms	-0,1806	0,0542	0,001			
Maximum LAVi, mL/m ²	-0,1057	0,1034	0,30			
LA ejection fraction, %	0,4860	0,0561	<.0001	0,3096	0,0475	<.0001

Abbreviations: see Table S9

Table S11. Parameters associated with LA booster strain

Variables	Simple linear regression			Multivariable linear regression		
	β	SE	P	β	SE	P
Apical 2-chamber view						
Age, years	0,0126	0,0316	0,69			
LV global longitudinal strain, %	0,0061	0,1662	0,97			
LV peak systolic dispersion, ms	-0,0070	0,0427	0,87			
Maximum LAVi, mL/m ²	-0,1497	0,0600	0,01			
LA ejection fraction, %	0,1782	0,0466	0,0002	0,1782	0,0466	<.001

	Apical 4-chamber view					
Age, years	0,0376	0,0311	0,22			
LV global longitudinal strain, %	-0,1037	0,1636	0,52			
LV peak systolic dispersion, ms	0,0291	0,0421	0,49			
Maximum LAVi, mL/m ²	-0,1467	0,0750	0,05			
LA ejection fraction, %	0,0814	0,0487	0,09			
	Apical biplane views					
Age, years	0,0328	0,0251	0,19			
LV global longitudinal strain, %	-0,0009	0,1331	0,99			
LV peak systolic dispersion, ms	-0,0060	0,0342	0,86			
Maximum LAVi, mL/m ²	-0,1571	0,0605	0,01	-0,1215	0,0632	0,057
LA ejection fraction, %	0,1060	0,0426	0,01	0,0791	0,0443	0,08

Abbreviations: see Table S9

Table S12. Reproducibility of LA size and strain values

	Interobserver agreement ICC(95%CI)	Intraobserver agreement ICC(95% CI)
Maximum LAV,mL (2Ch)	0.897(0.762-0.958)	0.873(0.668-0.955)
LA reservoir strain,%(2Ch)	0.788(0.523-0.912)	0.870(0.660-0.954)
LA conduit strain,%(2Ch)	0.965(0.786-0.990)	0.975(0.699-0.994)
LA booster strain,%(2Ch)	0.759(0.492-0.897)	0.877(0.675-0.957)
Maximum LAV,mL (4Ch)	0.888(0.729-0.955)	0.940(0.833-0.979)
LA reservoir strain,%(4Ch)	0.919(0.807-0.967)	0.961(0.891-0.987)
LA conduit strain,%(4Ch)	0.936(0.846-0.974)	0.952(0.866-0.983)
LA booster strain,%(4Ch)	0.738(0.446-0.888)	0.863(0.641-0.952)
Maximum LAV,mL (BIP)	0.895(0.757-0.957)	0.906(0.746-0.967)
LA reservoir strain,%(BIP)	0.948(0.717-0.984)	0.958(0.843-0.987)
LA conduit strain,%(BIP)	0.963(0.878-0.987)	0.981(0.931-0.994)
LA booster strain,%(BIP)	0.853(0.672-0.939)	0.908(0.753-0.968)

Abbreviations:LAV, left atrial volume; ICC, intraclass correlation coefficient; CI, confidence interval; see Table S2

Table S13. The comparison between AFI-LA analyses and traditional methods for LA parameters

	AFI-LA analyses	Traditional methods	P-value
LA volumetric parameters			
Maximum LAVi, mL/m ² (2Ch)	24.4(7.0)	23.0(3.5)	0,52
Minimum LAVi, mL/m ² (2Ch)	9.8(4.1)	8.9(2.3)	0,5
LA pre-A volume index, mL/m ² (2Ch)	17.9(5.7)		

Maximum LAVi, mL/m ² (4Ch)	21.7(5.6)	22.8(8.0)	0,58
Minimum LAVi, mL/m ² (4Ch)	8.7(3.2)	7.5(3.1)	0,25
LA pre-A volume index, mL/m ² (4Ch)	14.1(4.4)		
Maximum LAVi, mL/m ² (BIP)	23.4(5.6)	23.1(5.5)	0,84
Minimum LAVi, mL/m ² (BIP)	9.2(3.4)	8.3(2.5)	0,40
LA pre-A volume index, mL/m ² (BIP)	16.1(4.7)		
LA functional parameters			
LA reservoir strain,%(2Ch)	34.0(7.1)	38.8(6.2)	0,01
LA conduit strain,%(2Ch)	17.8(6.1)		
LA booster strain,%(2Ch)	16.1(4.5)		
LA emptying volume, mL(2Ch)	24.5(7.4)		
LA emptying volume index, mL/m ² (2Ch)	14.6(4.1)		
LA ejection fraction (2Ch),%	60.4(8.7)		
LA reservoir strain,%(4Ch)	31.5(6.8)	36.9(5.5)	0,003
LA conduit strain,%(4Ch)	18.5(6.6)		
LA booster strain,%(4Ch)	12.6(4.4)		
LA emptying volume, mL(4Ch)	21.7(6.4)		
LA emptying volume index, mL/m ² (4Ch)	12.9(3.5)		
LA ejection fraction (4Ch)	60.0(8.6)		
LA reservoir strain,%(BIP)	32.7(6.3)	37.8(5.8)	0,003
LA conduit strain,%(BIP)	18.1(6.0)		
LA booster strain,%(BIP)	14.5(3.6)		
LA emptying volume, mL(BIP)	23.7(6.3)		
LA emptying volume index, mL/m ² (BIP)	14.1(3.4)		
LA ejection fraction,%(BIP)	61.0(7.9)		
Time per method,seconds	112(14)	337(37)	<.0001

Data are expressed as mean(SD)

Abbreviations: see Table S2