SUPPLEMENTAL MATERIAL

Data S1.

Supplemental Methods

Gated acquisition sequences:

- Cine sequences: Retrospective-gated balanced steady-state free-precession (SSFP) cine imaging was performed during expiratory breath hold. Thirteen to 18 contiguous 8-mm slices were acquired in a short- axis (SAX) plane followed immediately by 11 to 15 contiguous 8-mm slices in a horizontal long-axis (HLA) plane. Typical imaging parameters were as follows: field of view (FOV), 320×320 mm; acquisition matrix, 192×172; sensitivity encoding (SENSE) factor, 1.7 to 2.0 (Cartesian k-space undersampling); repetition time, 2.8 to 3.4 ms; echo time, 1.4 to 1.7 ms; flip angle, 60°; reconstructed voxel size, 1.4×1.4×8 mm. For each acquired plane 25 phases over the cardiac cycle were reconstructed. For the radial long-axis slices centered on the SAVV annulus and separated by a rotation of 15°, two slices per breath-hold were acquired. Typical imaging parameters were as follows: FOV, 320×280 mm; SENSE factor, 1.7; repetition time, 2.7 ms; echo time, 1.4 ms; flip angle, 60°; reconstructed voxel size, 1.4×1.4×8 mm. For each acquired plane 25 phases over the cardiac cycle were reconstructed.
- MOLLI sequences: For the native T1 acquisition, a single breath-hold seconds-based MOLLI scheme (5s(3s)5s) with balanced SSFP readout was performed on a basal and midventricular SAX slice. Ten to 15 minutes after a 0.2 ml/kg (0.1 mmol/kg) bolus of intravenous gadoterate meglumine (Dotarem®, Guerbet, the Netherlands), a (4s(1s)3s(1s)2s) MOLLI scheme was performed. Typical imaging parameters were as follows: FOV, 300×300 mm; SENSE factor, 2; flip angle, 35°; voxel size, 2.0×2.0×10 mm.

- Velocity mapping of the aorta: Through-plane phase-contrast imaging at expiratory breath-hold at the level of the proximal ascending aorta. Typical imaging parameters were as follows: encoding velocity (VENC), 200 cm/s; FOV, 300×300 mm; SENSE factor, 1.75; repetition time, 5.1 ms; echo time, 3.1 ms; flip angle, 15°; reconstructed voxel size, 1.0×1.0×10 mm.

Ungated real-time acquisition sequences:

Forty to 75 consecutive ungated SSFP frames were acquired every 36 to 45 milliseconds at each of 13 to 18 contiguous 8-mm slices in the SAX plane, and 50 consecutive frames were acquired at approximately the same temporal resolution for 11 to 15 contiguous 8-mm slices in the HLA plane. Typical imaging parameters were as follows: FOV, 320×335 mm; matrix, 88×70 (rest) to 80×60 (peak ex.); SENSE factor, 2; repetition time, 1.8 ms; echo time, 0.8 ms; flip angle, 50°; reconstructed voxel size, 2.6×2.6×8 mm. Sufficient frame repetitions were programmed to include at least one complete respiratory cycle (for accurate gating of cardiac translation). The number of frame repetitions could be reduced for each increase in exercise intensity due to tachypnea during exercise. Thus, scan duration was minimized while enabling sufficient data to include multiple cardiac cycles and at least one complete respiratory cycle. Typically, resting scan durations of about 100 seconds were reduced to 60 seconds at peak exercise.

Table S1. Baseline characteristics in sRV patients and healthy controls.

Parameter	**TGA-Mustard/Senning N = 23**	**ccTGA N= 10**	**Healthy controls N = 12**	**P value**
Age, y	**34 ± 7**	**45 ± 7**	**39 ± 10**	**0.001**
Female sex	6 (26)	2 (20)	3 (25)	0.931
BMI, kg/m^2	23.1 ± 3.6	24.6 ± 3.9	25.9 ± 4.2	0.120
NYHA class, I/II/III	14 (61)/ 7 (30)/ 2 (9)	7 (70)/ 3 (30)/ 0 (0)	12 (100)/ 0/ 0	0.125
Medical treatment				
Beta blocker	**3 (13)**	**4 (40)**	**0**	**0.032**
ACE-I/ARB	**9 (39)**	**3 (30)**	**0**	**0.044**
Loop diuretic	1 (4)	0	0	0.613
ECG				
Heart rhythm, sinus/junctional/AF	22 (96)/ 1 (4)/ 0	8 (80)/ 1 (10)/ 1 (10)	12 (100)/ 0/ 0	0.288
Heart rate, bpm	**79 ± 17**	**71 ± 18**	**64 ± 4**	**0.024**
NT-proBNP, ng/L	**183 (89 – 299)**	**258 (124 – 642)**	**38 (35 - 52) N = 5**	**0.003**
Echocardiogram at rest				
SAVV regurgitation, none-to-mild/moderate/severe	**9 (39)/ 13 (57)/ 1 (4)**	**1 (10)/ 5 (50)/ 4 (40)**	**12 (100)**	**<0.001**
CPET				
Peak power output, W	180 ± 51	174 ± 37	225 ± 62	0.051
Peak VO_2, mL/kg/min	28.6 ± 8.3	25.6 ± 7.1	33.7 ± 9.8	0.097

Peak VO_2, % of predicted peak VO_2	**70 (64 – 92)**	**82 (61-88)**	**103 (86 - 112)**	**<0.001**
Resting CMR measures				
sRVEDVi, mL/m2	**127.1 ± 35.5**	**126.8 ± 40.6**	**87.3 ± 21.2**	**0.005**
SVi, mL/m2	**40.6 ± 7.7**	**40.8 ± 7.1**	**53.4 ± 13.7**	**0.001**
sRVEF, %	**40 ± 7**	**42 ± 10**	**61 ± 5**	**<0.001**
SAVV RF, %	**18 ± 12**	**28 ± 11**	**4 ± 7**	**0.006**
sRVESPVR	**0.86 ± 0.29**	**0.92 ± 0.50**	**2.17 ± 1.02**	**<0.001**

Values are mean ± SD, median (IQR) or number (%). ACE-I/ARB indicates angiotensin converting enzyme inhibitor or angiotensin receptor blocker; AF, atrial fibrillation; BMI, body mass index; CMR, cardiac magnetic resonance; CPET, cardiopulmonary exercise testing; ECG, electrocardiogram; EF, ejection fraction; EDV, end-diastolic volume; i, indexed to body surface area; NYHA, New York Heart Association; RF, regurgitation fraction; SAVV, systemic atrioventricular valve; sRV, systemic right ventricular; sRVESPVR, sRV end-systolic pressure/volume relationship; SV, stroke volume. Note that for the healthy controls the data of the systemic left ventricle is listed under the sRV heading.

Table S2. exCMR metrics.

	TGA-Mustard/Senning patients			
	Rest	Low intensity	Moderate intensity	Peak intensity
sRVEDVi, mL/m2	127.1 ± 35.5	121.1 ± 35.6	116.3 ± 34.5	113.3 ± 34.1
sRVESVi, mL/m2	78.0 ± 30.5	73.9 ± 31.3	71.2 ± 30.8	68.6 ± 30.1
sRVSVi, mL/m2	49.0 ± 9.7	47.1 ± 9.8	45.1 ± 9.6	44.8 ± 10.0
sRVEF, %	40 ± 7	41 ± 9	41 ± 9	41 ± 9
estimated SAVV RF, %	16 ± 10	16 ± 12	15 ± 11	15 ± 13
LVEDVi, mL/m2	69.2 ± 15.8	63.5 ± 16.8	60.3 ± 17.5	58.4 ± 17.9
LVESVi, mL/m2	25.9 (20.3 – 31.6)	22.7 (17.6 – 26.6)	18.9 (15.4 – 24.2)	17.9 (13.7 – 22.6)
LVSVi, mL/m2	40.6 ± 7.7	39.2 ± 7.7	37.9 ± 6.8	37.4 ± 6.8
LVEF, %	63 (56 – 65)	67 (59 – 68)	67 (58 – 70)	69 (63 – 71)
HR, bpm	69 ± 10	112 ± 17	139 ± 21	159 ± 21
CI, L/min/m2	2.76 ± 0.40	4.30 ± 0.69	5.20 ± 0.83	5.87 ± 0.90
SBP, mmHg	119 ± 12	143 ± 19	157 ± 21	163 ± 21
RVESPVR, mmHg/mL	0.86 ± 0.29	1.11 ± 0.41	1.26 ± 0.47	1.35 ± 0.48

	ccTGA patients			
	Rest	Low intensity	Moderate intensity	Peak intensity
sRVEDVi, mL/m2	126.8 ± 40.6	128.3 ± 40.4	130.0 ± 40.5	130.2 ± 39.7
sRVESVi, mL/m2	76.1 ± 36.8	73.2 ± 36.2	72.8 ± 35.1	71.6 ± 35.0
sRVSVi, mL/m2	50.6 ± 9.0	55.1 ± 10.4	56.8 ± 12.8	58.6 ± 13.6
sRVEF, %	42 ± 10	45 ± 10	46 ± 10	47 ± 11
LVEDVi, mL/m2	68.1 ± 12.5	70.2 ± 17.2	71.2 ± 18.5	70.9 ± 19.1
LVESVi, mL/m2	27.3 ± 11.0	26.0 ± 7.7	25.5 ± 7.7	23.8 ± 7.6
LVSVi, mL/m2	40.9 ± 7.1	44.2 ± 10.9	45.7 ± 12.8	47.2 ± 13.0

LVEF, %	60 ± 6	63 ± 5	64 ± 6	67 ± 5
HR, bpm	70 ± 13	98 ± 27	120 ± 34	138 ± 38
CI, L/min/m2	2.80 ± 0.40	4.14 ± 0.75	5.21 ± 1.06	6.22 ± 1.37
SBP, mmHg	121 ± 15	139 ± 23	156 ± 24	163 ± 29
RVESPVR, mmHg/mL	0.92 ± 0.50	1.11 ± 0.63	1.22 ± 0.64	1.31 ± 0.67

	Healthy controls			
	Rest	Low intensity	Moderate intensity	Peak intensity
LVEDVi, mL/m2	87.3 ± 21.2	89.0 ± 18.4	89.2 ± 20.2	85.8 ± 19.5
LVESVi, mL/m2	33.9 ± 9.2	28.7 ± 5.5	27.5 ± 7.4	26.6 ± 6.7
LVSVi, mL/m2	53.4 ± 13.7	60.2 ± 14.2	61.7 ± 14.9	59.2 ± 15.5
LVEF, %	61 ± 5	67 ± 4	69 ± 5	69 ± 6
estimated SAVV RF, %	4 ± 7	3 ± 4	2 ± 6	4 ± 4
RVEDVi, mL/m2	86.7 ± 24.5	86.9 ± 22.2	85.6 ± 22.9	79.9 ± 20.8
RVESVi, mL/m2	35.4 ± 12.2	28.1 ± 8.4	25.2 ± 8.6	22.5 ± 6.6
RVSVi, mL/m2	51.3 ± 13.1	58.8 ± 15.1	60.5 ± 15.1	57.3 ± 16.2
RVEF, %	60 ± 6	68 ± 5	71 ± 4	72 ± 5
HR, bpm	64 ± 4	100 ± 8	124 ± 12	144 ± 14
CI, L/min/m2	3.38 ± 0.91	6.32 ± 1.93	8.19 ± 2.58	8.94 ± 2.85
SBP, mmHg	142 ± 20	170 ± 23	191 ± 23	200 ± 25
LVESPVR, mmHg/mL	2.17 ± 1.02	2.85 ± 0.75	3.45 ± 1.09	3.71 ± 1.17

Values are mean ± SD or median (IQR). EF indicates ejection fraction; EDV, end-diastolic volume; i, indexed to body surface area; LV, left ventricular; RF, regurgitant fraction; SAVV, systemic atrioventricular valve; sRV, systemic right ventricular; sRVESPVR, sRV end-systolic pressure/volume relationship; and SV, stroke volume.

Table S3. **Baseline characteristics at rest and CPET data in TGA-Mustard/Senning patients with a preserved or impaired exercise capacity according to the median %ppVO2.**

	TGA-Mustard/Senning		
	Preserved exercise capacity N=12	Impaired exercise capacity N=11	*P* value
Peak VO_2, % of predicted peak VO_2	**86 ± 12**	**64 ± 3**	**<0.001**
Age, y	33 ± 5	35 ± 8	0.338
Female	2 (17)	4 (36)	0.371
Mustard/ Senning	2 (17) / 10 (83)	5 (45.5) / 6 (54.5)	0.193
NYHA class, I/II/III	**11 (92) / 1 (8)**	**3 (27) / 6 (55) / 2 (18)**	**0.006**
Medical treatment			
Beta blocker	0	3 (27)	0.093
ACE-I/ARB	**2 (17)**	**7 (64)**	**0.036**
Loop diuretic	0	1 (9)	0.478
ECG			
Heart rhythm, sinus/junctional/AF	12 (100) / 0 / 0	10 (91) / 1 (9) / 0	0.478
Heart rate, bpm	82 ± 19	77 ± 15	0.465
QRS width, ms	103 ± 18	104 ± 16	0.891
Hematocrit	0.430 ± 0.030	0.427 ± 0.036	0.839
NT-proBNP, ng/L	213 (84 – 295)	181 (89 – 415)	>0.999

Echocardiogram at rest			
TAPSE, mm	11 ± 4	11 ± 2	0.617
SAVV regurgitation, mild/moderate/severe	6 (50) / 6 (50) / 0	3 (27) / 7 (64) / 1 (9)	0.361
CPET			
Peak VO_2, mL/kg/min	**33.3 ± 8.2**	**23.5 ± 4.9**	**0.002**
Heart rate reserve, bpm	**97 ± 11**	**81 ± 20**	**0.032**
Anaerobic threshold, % of peak VO_2	**60 ± 12**	**42 ± 9**	**<0.001**
Resting CMR measures			
sRV EDVi, mL/m2	129.6 ± 41.8	124.7 ± 30.2	0.747
sRV/LV EDVi ratio	1.9 ± 0.4	1.8 ± 0.6	0.566
SVi, mL/m2	39.5 ± 9.5	41.8 ± 5.5	0.485
sRV mass i, g/m2	79.7 ± 14.2	86.9 ± 21.5	0.578
sRV EF, %	39 ± 5	41 ± 9	0.345
GLS, %	-11.6 ± 2.4	-11.6 ± 2.7	0.974
GCS, %	-15.5 ± 3.0	-16.1 ± 4.2	0.632
sRVESPVR	0.81 ± 0.20	0.91 ± 0.37	0.437
Native T1 of septal myocardium, ms	1018 ± 37	1030 ± 43	0.481
ECV of septal myocardium, %	26.9 ± 2.2	27.2 ± 3.2	0.801

Values are mean ± SD, median (IQR) or number (%). ACE-I/ARB indicates angiotensin converting enzyme inhibitor or angiotensin receptor blocker; AF, atrial fibrillation; CMR,

cardiac magnetic resonance; CPET, cardiopulmonary exercise testing; ECG, electrocardiogram; EF, ejection fraction; ECV, extracellular volume; EDV, end-diastolic volume; GLS, global longitudinal strain; GCS, global circumferential strain; i, indexed to body surface area; LV, left ventricular; NYHA, New York Heart Association; SAVV, systemic atrioventricular valve; sRV, systemic right ventricular; sRVESPVR, sRV end-systolic pressure/volume relationship; SV, stroke volume; and TAPSE, tricuspid annular plane systolic excursion.