Introduction: The application of compressed sensing presumes a sampling scheme with incoherent, noise-like aliasing artifacts. In practical cardiovascular MRI this objective is usually not fully met and a spatial variation of aliasing artifacts is induced by varying signal intensity, contrast, motion, and geometry. In particular, the inhomogeneous sensitivity profile of a 32-channel cardiac coil array leads to strong streak artifacts in the proximity of the chest-wall.

Methods: Reconstruction: In this work, the k-t radial SPARSE SENSE (k-t RASPS) [1] image reconstruction method is extended by a new spatiotemporal adaptively regularized reconstruction scheme (k-t STARR). Instead of using a scalar regularization parameter $\lambda$, a regularization matrix $\Lambda$ is used, which adapts the temporal regularization strength to the local magnitude of the aliasing artifacts using the temporal total variation $\Lambda_n = \|x_n\|_\text{TV}$ for pixel $n$ from the non-iterative gridding solution $x$. The optimization problem $\text{argmin}_{x}(\|Ax - b\|_2^2 + \lambda_1 \|\psi_1 x\|_1 + \lambda_2 \|\psi_2 x\|_1)$ is solved with $\psi_1$ / $\psi_2$ being the finite difference along the temporal / spatial dimensions, $b$ the data in k-t space, and $A$ the system matrix containing the discrete non-uniform Fourier transform and the coil sensitivities. Temporal regularization $\lambda_1$ was set to eliminate all coherent aliasing artifacts from the cardio-vascular structures and $\lambda_2$ was set to a moderate regularization to suppress staircase artifacts induced by the temporal regularization. For fair comparison the matrix $\Lambda$ was scaled to have a value of $\Lambda_n \approx 1$ for all pixel $n$ in the region of the ventricle.

Acquisition: Short-axis cardiac datasets from 8 healthy volunteers were acquired on a Philips 3T Achieva using a 32 channel coil array under free breathing, a radial golden angle trajectory [3], and a spoiled gradient echo sequence. The parameters were $\text{TE/TR} = 1.3 / 3.4$ ms, flip angle = 15°, pixel bandwidth = 857.8 Hz, FOV = 400 x 400 mm², and spatial resolution = 2 x 2 x 8 mm³. The k-space data was reordered to 13 spokes per time frame, which leads to an undersampling factor of $R = 24$. The coil sensitivities $S$ were estimated from a separate calibration scan. Additionally, a breath-hold ECG triggered dataset was acquired for each volunteer. Written informed consent was obtained in all cases prior to examination.

Results: The gridding solution (Fig. 1a) is clearly dominated by undersampling artifacts. The $\Lambda$-map (Fig. 1b) appears to be a good estimation for the distribution of the aliasing artifacts. The k-t RASPS reconstruction exhibits strong aliasing artifacts, especially near the chest-wall ranging into the right ventricle (Fig. 1c), which are clearly reduced in the k-t STARR reconstruction (Fig 1d). M-Mode like plots show that k-t STARR does not affect the temporal fidelity in the cardio-vascular structures despite the suppression of the strong oscillating artifacts near the chest-wall (Fig. 2).

Conclusion: The proposed method reduces the residual aliasing artifacts that are typical for dynamic cardiovascular MRI with 32-channel coil arrays without compromising the temporal fidelity of the cardiac region.