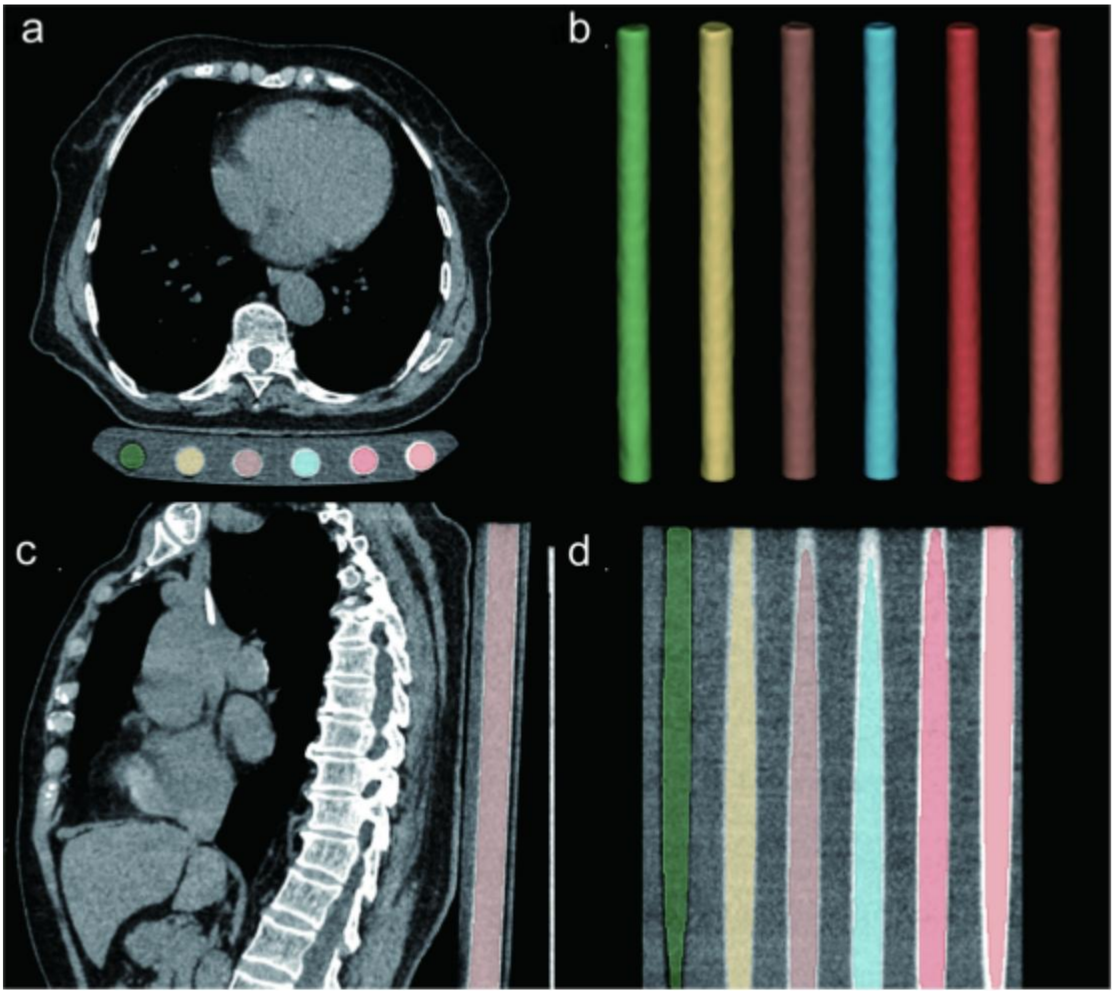
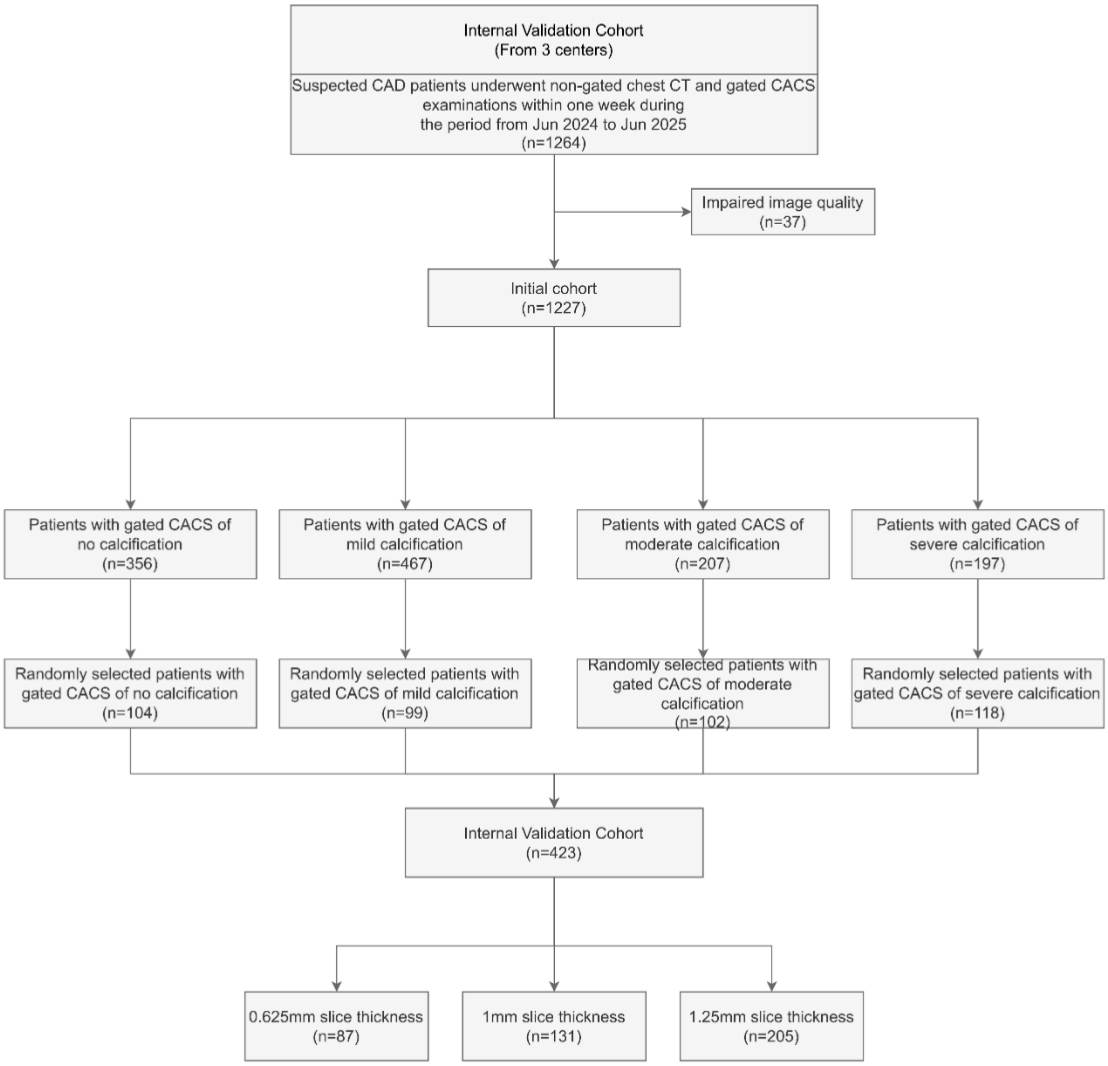
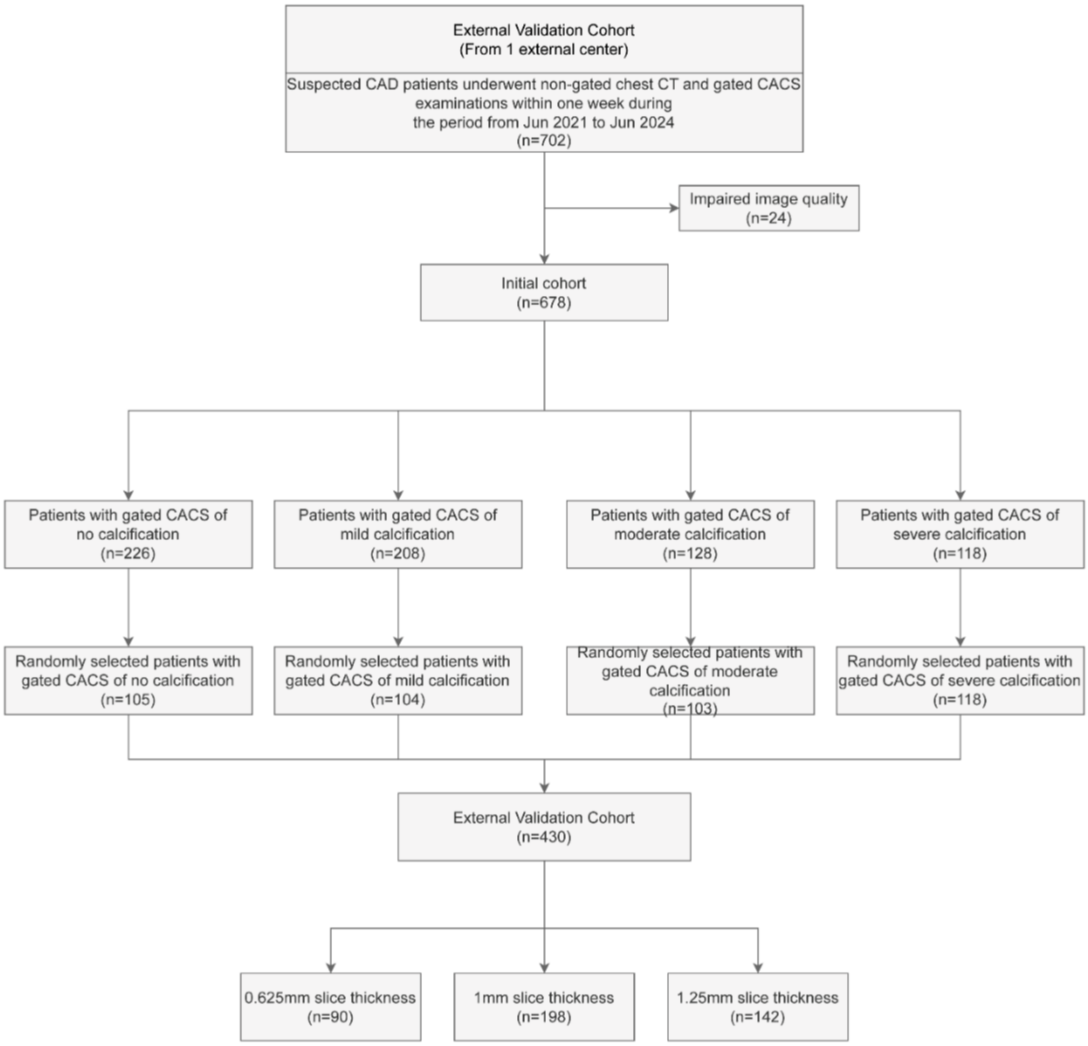


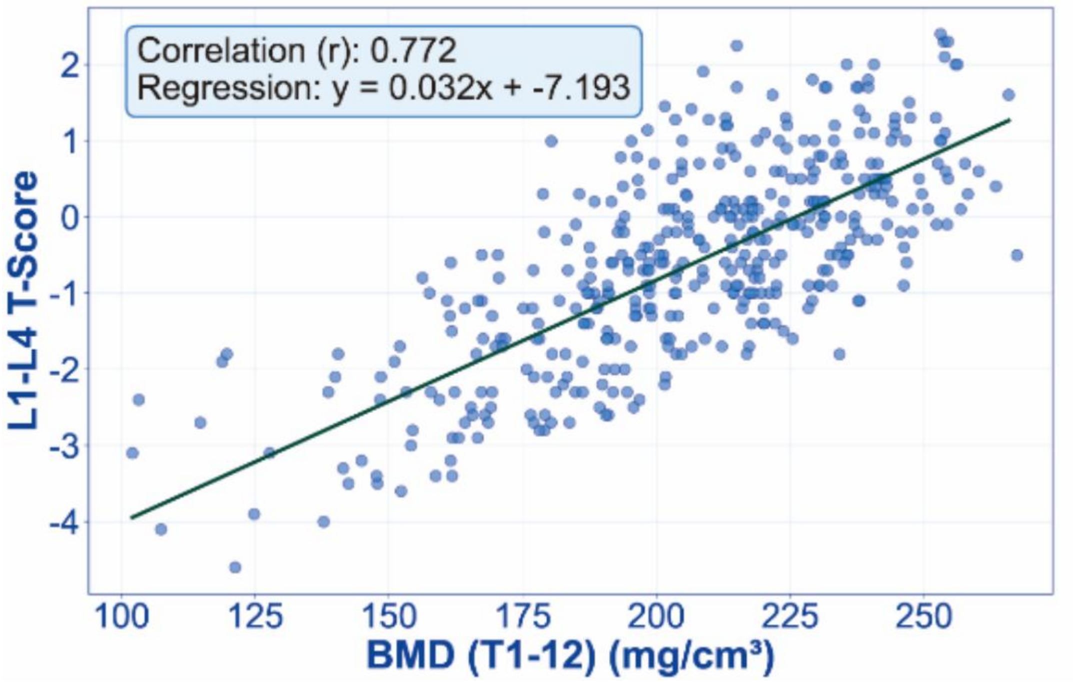
Supplementary Figure 1 Automated segmentation and visualization of the calibration phantom using a custom 3D nnU-Net model. A: Axial non-contrast chest CT image demonstrating the placement of the calibration phantom beneath the patient's torso. The colored overlays represent the automated segmentation masks generated by the 3D nnU-Net model for the six solid hydroxyapatite inserts; B: Three-dimensional volume rendering of the segmented phantom cylinders, highlighting the model's ability to capture spatial continuity and geometric integrity along the Z-axis; C: Sagittal reconstruction illustrating the longitudinal alignment of the phantom relative to the thoracic spine; D: Coronal multi-planar reconstruction exhibiting the precise coverage of segmentation masks. The color-coded masks correspond to hydroxyapatite concentrations in ascending order: (1) Green (0 mg/cm^3); (2) Yellow (50 mg/cm^3); (3) Brown (100 mg/cm^3); (4) Cyan (150 mg/cm^3); (5) Red (200 mg/cm^3); and (6) Pink (300 mg/cm^3). This automated segmentation pipeline enables the precise extraction of reference Hounsfield Units from each insert to establish scanner-specific calibration equations (as detailed in Supplementary Table 1), ensuring quantitative accuracy for vertebral bone mineral density assessment across multi-vendor equipment.



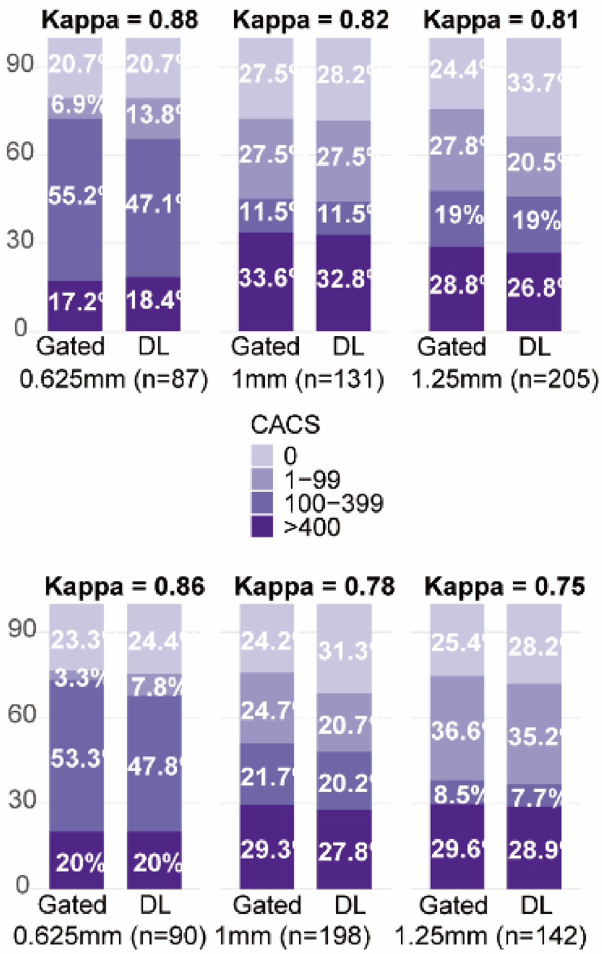
Supplementary Figure 2 Sample selection for the internal validation of the deep learning model. The subjects were stratified into four distinct groups according to their coronary artery calcium score obtained through the gated method: (1) 0 (no calcification); (2) 1–99 (mild calcification); (3) 100–399 (moderate calcification); and (4) ≥ 400 (severe calcification). From each group, approximately 100 patients were randomly selected to constitute the final internal validation cohort (n = 423). CACS: Coronary artery calcium score; CT: Computed tomography; DL: Deep learning.



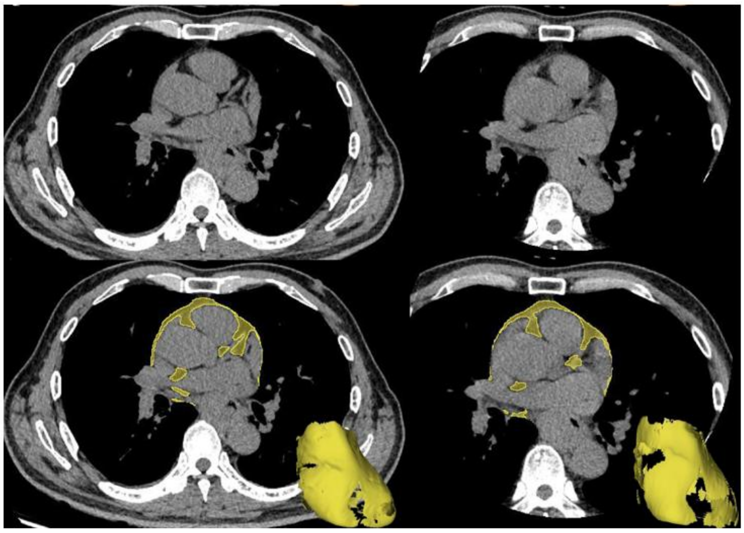
Supplementary Figure 3 Sample selection for the external validation of the deep learning model. The subjects were stratified into four distinct groups according to their coronary artery calcium score obtained through the gated method: (1) 0 (no calcification); (2) 1–99 (mild calcification); (3) 100–399 (moderate calcification); and (4) ≥ 400 (severe calcification). From each group, approximately 100 patients were randomly selected to constitute the final internal validation cohort (*n* = 430). CACS: Coronary artery calcium score; CT: Computed tomography; DL: Deep learning.



Supplementary Figure 4 Spearman correlation of artificial intelligence-derived bone mineral density *vs* dual-energy X-ray absorptiometry T-score (left).



Supplementary Figure 5 Weighted Kappa statistics for coronary artery calcium severity grading across internal and external cohorts (0.625 mm *vs* 1.25 mm slices).



Supplementary Figure 6 Cross-modality segmentation consistency. A 49-year-old male patient underwent both a standard non-contrast chest computed tomography and a coronary computed tomography angiography on the same day. Epicardial adipose tissue segmentation using the specialized pericardial model on non-contrast and electrocardiographic-gated non-contrast images, with epicardial adipose tissue highlighted in yellow.

Supplementary Table 1 Scanner-specific linear regression equations for converting computed tomography attenuation values (hounsfield unit) to bone mineral density across various manufacturers and models

Manufacturer	CT model	KVP	n	R-squared	Equation
GE Healthcare	Discovery CT750 HD	120	65	0.882	BMD = 0.8722 × HU + 16.2086
	Revolution CT	120	44	0.851	BMD = 0.7321 × HU - 1.5692
	Optima CT680 Series	120	40	0.836	BMD = 0.8587 × HU + 0.0412
	Optima CT660	120	40	0.828	BMD = 0.8239 × HU + 1.5108

	LightSpeed16	120	45	0.805	BMD = 0.7768 × HU + 0.5034
	LightSpeed VCT	120	45	0.812	BMD = 0.7643 × HU + 0.0128
	BrightSpeed	120	45	0.825	BMD = 0.7308 × HU + 10.5062
Siemens Healthineers	SOMATOM go.Top	120	44	0.815	BMD = 0.6938 × HU + 5.5062
	SOMATOM Force	120	43	0.822	BMD = 0.6853 × HU + 4.2286
	SOMATOM Definition AS+	120	54	0.845	BMD = 0.6978 × HU + 3.0189
United imaging healthcare	uCT 960+	120	53	0.893	BMD = 0.7903 × HU + -1.8134
	uCT 780	120	55	0.821	BMD = 0.7389 × HU + 12.1302
	uCT 550	120	45	0.832	BMD = 0.8154 × HU + 6.4843
Philips healthcare	iCT 256	100	45	0.841	BMD = 0.8286 × HU + -4.8116
	Incisive CT	120	45	0.802	BMD = 0.9214 × HU - 2.5037
	Brilliance16	120	45	0.845	BMD = 0.7459 × HU + 13.8217

We included chest computed tomography scans performed on 22 distinct computed tomography scanner models from seven manufacturers with varying hardware configurations. The study utilized scanners from GE Healthcare (United States), Siemens Healthineers (Germany), United Imaging Healthcare (China), Philips Healthcare (Netherlands). All images were acquired using helical acquisition mode with automated tube current modulation. The reference tube voltage was set to 120 kVp for the majority of scanners, with the exception of the Philips iCT 256 (100 kVp). Images were reconstructed with a standard kernel into a 512 × 512 matrix. BMD: Bone mineral density; CT: Computed tomography; HU: Hounsfield unit; kVp: Kilovoltage peak.

Supplementary Table 2 Detailed model architectures

Model construction	**Operations**

details	
CT image preprocess	Spatial normalization: Crop the void area (tissue-free area) in the CT images; resample the CT images into 0.68× 0.68× 1.0 (median spacing of C1-central cohort); randomly crop in the patch size of 96 × 160 × 160 to feed into the model. Intensity normalization: Clip the intensity in the 99% of their intensity values; use the Z-score normalization method
Data augmentation	Spatial data augmentation: Elastic deformation; random rotation; random scale; mirror transform. Intensity data augmentation: Gamma transform
Details	Training strategies: deep supervision; clip gradient to avoid divergence; early stop if the dice score does not improve in 50 epochs. Loss function: Cross entropy loss and dice loss function was implemented for optimization. Optimizer: Stochastic gradient descent, weight decay: 3×10^{-5}, momentum: 0.99; poly learning rate decay method, initial learning rate: 0.01, max epochs: 500 Model development: Basic structure: 3D convolutional layer, Leaky ReLU, and Instance Normalization; kaiming normal distribution for network initialization. Validation data augmentation: Stride the whole CT images using a fixed patch size; mirror in the sagittal, axial, and coronal plane; gaussian filter to focus on the central area in each patch

Skeletal assessment: The trabecular bone region was isolated from TotalSegmentator vertebral segmentations by excluding cortical bone (defined as voxels >300 HU), and the average volumetric BMD was calculated using the aforementioned calibration formulas (Dice score 0.975). Coronary artery calcium: A custom two-stage deep learning framework was employed. Step 1 utilized a modified 3D U-Net with a "Bottle-Neck" design to coarsely segment the cardiac region, reducing computational cost and false positives. Step 2 applied a second 3D U-Net within the localized heart region to finely segment calcified lesions and classify them into specific coronary branches (LAD, LCX, RCA, LM). The Agatston score was calculated based on standard protocols. Epicardial adipose tissue: Epicardial adipose tissue was defined as adipose tissue located between the myocardium and the visceral pericardium.

Pericardial annotation was performed on 110 external non-contrast chest CTs to train a 3D U-Net-based pericardial segmentation model (Dice score 0.935). EAT volume and density were quantified by thresholding voxels between -190 HU and -30 HU within the segmented pericardial mask after median filtering.

Supplementary Table 3 Analysis of coronary artery calcium scoring: Kappa coefficients stratified by slice thickness in internal and external validation cohorts

Validation cohort	**Slice thickness (mm)**	**LAD**	**LCX**	**RCA**	**All vessels**
Internal validation	0.625	0.901	0.861	0.983	0.877
	1	0.844	0.768	0.915	0.821
	1.25	0.826	0.843	0.929	0.811
External validation	0.625	0.886	0.944	0.965	0.862
	1	0.761	0.814	0.951	0.784
	1.25	0.822	0.751	0.939	0.751

Values are presented as Kappa coefficients. Agreement analysis evaluates the consistency of coronary artery calcium score categorization derived from the deep learning model compared with the ground truth. Analysis was stratified by image slice thickness (0.625 mm, 1.0 mm, and 1.25 mm). LAD: Left anterior descending artery; LCX: Left circumflex artery; RCA: Right coronary artery.