Working with heart

Cardiovascular CT Solutions
GE Healthcare’s cardiovascular solution in Computed Tomography is a continuous engagement for improved diagnosis in an early stage approach. Cardiovascular disease is the worldwide leading cause of mortality. Progress in the field of cardiac imaging has encouraged the development of a non-invasive technique that provides a broad spectrum of clinical information.

Cardiac CT has made great progress over the last years and established itself as a routine procedure in many centers and offers the potential to visualize earlier stages of coronary atherosclerosis and help clinicians optimize treatment strategies.
Clinically relevant innovation in cardiovascular imaging

Ultra low dose
SnapShot Pulse acquisition with prospective gating and ASiR™ iterative reconstruction technology enables ultra low dose not only for coronary CTA but across cardiovascular exams, enabling cardiac CT as low as 1mSv.

Adaptive Imaging
Acquisition protocols are easily adapted to the clinical need of the individual patient for optimal diagnostic results at lowest dose. Intelligent system design helps to manage high and unstable heart rates in prospective and retrospective manner.

Automated analysis
Be it on Advantage Workstation™ or access from anywhere through AW Server, GE provides outstanding applications for cardiovascular analysis. Automated coronary and heart analysis by 0-click segmentation and tracking, autobone, vessel analysis, perfusion.

High-definition CT
True high-definition imaging* with exceptional image quality—with new levels of resolution, low contrast detectability (LCD) and noise reduction—enables a new standard in anatomical visualization even for the most challenging exams with stent evaluations, plaque or high amount of calcifications.

Gemstone Spectral Imaging
Gemstone Spectral Imaging* is a revolutionary feature with the potential to help characterize lesions through the separation of materials, improving image quality and reducing artifacts from implanted devices.

* available on Discovery™ CT750 HD
The ability to determine calcium scores helps to establish a patient’s cardiovascular disease risk. With cardiac CT scanning, calcium scoring is easy to put into place, and thanks to SmartScore, plaque burden is quickly quantified.

**SmartScore**

Advanced analysis tool for detecting & scoring cardiac calcium plaque burden
- Tool for assessing patients overall risk of coronary artery disease
- Non-Invasively quantify the amount of calcium burden

**Coronary artery analysis with heavy calcium burden**

**Patient History**
Male with chest pain and positive ECG changes. A calcium score scan was performed initially which showed very high AJ130 score at 4538.

**Technique**
- Scanner: Discovery CT750 HD
- Heart rate: 42-60 BPM
- SnapShot Pulse, ASiR
- Tube Voltage: 100 kV
- Tube Current: 400 mA
- Dose: 0.98 mSv* (DLP= 70 mGy.cm)

**Findings**
Atheroma in Left Main Stem. There is a long section of occlusion mid segment in the Left Anterior Descending Artery. The dominant Right Coronary Artery is diffusely diseased with severe sequential stenosis. The Circumflex Artery (not shown) has diffuse calcified atheroma, but there is no evidence of severe stenosis.

Perfusion maps (performed with CardIQ Xpress) shows perfusion defects in the Left Anterior Descending artery and Right coronary artery territories

**Population Distribution for Calcium Scores**

Coronary CTA at 1 mSv with high calcium scores can be successfully diagnosed with High-definition imaging. Perfusion maps to give additional information on degree of disease.
Low dose cardiac CT scanning with prospective SnapShot Pulse acquisition allows clinicians to lower dose drastically. Increased spatial resolution permits for enhanced assessment in challenging cases involving stents. These technologies, when combined with the powerful CardIQ Xpress Elite suite, allow for fast and thorough analysis of the coronary tree and the aorta.

**CardIQ Xpress 2.0**

*Application dedicated to coronary and cardiac analysis: automated, simple & quick*

- Imaging of cardiac morphology, coronary artery, and assessment of relative perfusion, bypass graft patency, post intervention follow-up, and functional assessment
- Automatic processing and loading of multi-phase data
- Auto coronary vessel analysis tracks coronary tree automatically
- Relative perfusion provides additional information to anatomical analysis

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**CASE**

**Dr. Sinitsyn • Federal Medicine and Rehabilitation Center - Moscow, Russia**

- **Patient History**
  Female patient with substernal chest pain on mild exertion.

- **Technique**
  Scanner: Discovery CT750 HD
  - Acquisition Mode: SnapShot Pulse, ASiR
  - Heart rate: 62 BPM
  - Tube Voltage: 80 kV
  - Tube current 400 mA
  - Dose: 0.56 mSv* (40 mGy.cm)

- **Findings**
  CTA found multiple plaques in LCA: proximal mixed plaque with 50% lumen stenosis and another mixed plaque in middle part with 50% lumen stenosis. LCX has mixed proximal stenosis over 50%. LMB has proximal mixed plaque with 80% stenosis of the lumen. RCX is normal.
  Patient was referred to interventional cardiology.

Obtained by ICRP using a chest factor of 0.014 DLP*
**Coronary stent analysis**

**CASE**

Dr. Roobottom and Dr. Morgan-Hughes • University Plymouth • Derriford, UK

- **Patient History**
  Male patient with multiple interventions needs coronary CTA for stent follow-up

- **Technique**
  - Scanner: Discovery CT750 HD
  - Heart rate: 55 BPM
  - SnapShot Pulse, ASiR
  - Tube Voltage: 100 kV
  - Tube Current: 750 mA
  - Dose: 1.8 mSv* (DLP= 127 mGy.cm)

- **Findings**
  The proximally based LAD stent appears entirely satisfactory. There is moderate stenosis in the LAD at the origin of the second diagonal. The remainder of the LAD is unremarkable.

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**Combined coronary and vascular assessment**

**CASE**

Dr. Sablayrolles • Centre Cardiologique du Nord • St. Denis, France

- **Patient History**
  Male patient with CAD history (previous myocardial infarction with LAD stent implant). The patient also had an aorto-aortic bypass put into place.
  A cardiovascular CT exam was performed.

- **Technique**
  - Scanner: Discovery CT750 HD
  - SnapShot Pulse, ASiR
  - Tube Voltage: 120 kVp
  - Tube Current: 650 mA
  - Coverage: 524 mm
  - Dose: 9.4 mSv* (DLP= 671 mGy.cm)

- **Findings**
  LCA with severe intra-stent restenosis. RCA with severe stenosis proximal to the aneurysm. Left ventricle dilation, with thrombus emerging from ventricular wall.
Revascularization follow-up

Dr. Pontone and Dr. Andreini • Centro Cardiologico Monzino • Milan, Italy

Patient History
Male patient, smoker, suffering from dyslipidemia has had 3 bypass graft implants as well as a stent (LCx) implant. Study is a follow-up for stent and bypass grafts.

Technique
Scanner: Discovery CT750 HD
- Heart rate: 55 BPM
- SnapShot Pulse, ASiR
- Tube Voltage: 100 kV
- Tube Current: 750 mA
- Dose: 1.8 mSv* (DLP= 127 mGy.cm)

Findings
The proximally based LAD stent appears entirely satisfactory. There is moderate stenosis in the LAD at the origin of the second diagonal. The remainder of the LAD is unremarkable.

Coronary imaging with unstable heart rhythm

Dr. Ghekiere, Dr. Djekic, Dr. Nchimi • St. Joseph • Liege, Belgium

Patient History
Male patient with a history of atrial fibrillation, presented with atypical precordialgia and dyspnea. Cardiovascular risk factors include arterial hypertension, dyslipidemia, family history of cardiovascular disease and smoking stopped over 4 years. A bicycle stress test was equivocal.

Technique
Scanner: LightSpeed™ VCT
- Snapshot Pulse and Adaptive prospective ECG-gating with large padding
- Tube Voltage: 120 kVp
- Average HR: 63 BPM; premature beat 110 BPM
- BMI: 35.08 kg/m²
- Dose: 4.4 mSv* (DLP= 315 mGy.cm)

Findings
RCA, LAD LCx show excellent image quality with no significant coronary stenosis.

Obtained by ICRP using a chest factor of 0.014DLP*

Adaptive Gating efficiently avoids premature beat of 110 BPM during prospective gating low dose acquisition and provides optimized image quality.
**CAD assessment at high heart rate and arrhythmia**

**CASE**

Dr. Sablayrolles • Centre Cardiologique du Nord • St. Denis, France

- **Patient History**
  Male patient with thoracic pain is sent for coronary CTA.

- **Technique**
  Scanner: Discovery CT750 HD
  - SnapShot (Burst) with ECG modulation
  - Average HR: 73 BPM, min 53 BPM, max 126 BPM
  - Tube Voltage: 120 kVp
  - Tube Current: 700 mA

- **Findings**
  Significant stenosis of the left main artery
  Due to the helical acquisition, dose for this case is higher with SnapShot Pulse.

**Adaptive imaging allows an optimized study of the coronary arteries with high heart rhythms and large variations during the acquisition.**

**Rule out of CAD**

**CASE**

Dr. Solacroup, Dr. Genest • Centre Hospitalier Provins, France

- **Patient History**
  Male patient, with diabetic arthritis.
  False positive stress test 3 years ago. CTA for rule out of coronary artery disease.

- **Technique**
  Scanner: Optima™ CT660
  - Acquisition Mode: SnapShot Pulse, ASiR
  - Average HR: 55 BPM
  - Tube Voltage: 100 kVp
  - Tube Current: 400 mA
  - Dose: 1.6 mSv* (117 mGy.cm)

- **Findings**
  Severe stenosis of the left coronary, moderate stenosis of the circumflex artery.

Obtained by ICRP using a chest factor of 0.014DLP*
Acute Myocarditis

Dr. Dambrin, Dr. De Cassin, Dr. Héran, Dr. Jégou • Parly II - Le Chesnay, France.

▶ Patient History
Young male patient with a recent episode of fever, has been admitted to emergency for acute chest pain. ECG demonstrated mild ST-elevation in antero-lateral leads. Regarding the minimal ECG abnormalities and the negative initial biomarkers, we performed a coronary CTA.

▶ Technique
Scanner: LightSpeed VCT
• Acquisition Mode: SnapShotPulse, ASiR
• Tube Voltage: 100 kVp
• Tube current: 500 mA

A delayed low-voltage acquisition (80 kV, 500 mA) has been performed five minutes after iodine injection.
• Dose: 2.9 mSv* (209 mGy.cm)

▶ Findings
Good image quality revealing a normal, non calcified coronary tree (Fig 1) without any stenosis or atheromatous plaque.
First acquisition: myocardial enhancement homogeneous without any defect.
Delayed acquisition: revealed hyperenhancement areas subepicardial (Fig 2) and intra mural (Fig 3). This late myocardial enhancement was located in the inferior and lateral wall of the left ventricle and had a patchy pattern (Fig 4) suggestive of a myocarditis. A cardiac MRI (Fig 4) performed on day 3 validated the myocarditis.
Analysis of myocardial enhancement patterns on delayed acquisition can reveal patchy, multifocal hyperenhanced areas suggesting inflammatory processes with good concordance with MRI results.

(1) G. Dambrin, Eur Radiology 2007; 17; 331-33
 Obtained by ICRP using a chest factor of 0.014DLP*

Congenital: Transposition of the Great Arteries

Dr. Stålhammar • The Queen Silvia Children’s Hospital, Gothenburg, Sweden

▶ Patient History
Young girl with transposition of the great arteries (TGA) and ventricular septum defect. Ultrasound is inconclusive especially regarding the pulmonary arteries, veins and possible aorto pulmonary collateral arteries.

▶ Technique
Scanner: Discovery CT750 HD
• Acquisition Mode: Auto mA/Smart mA (NI 28), ASiR
• Tube Voltage: 80 kVp
• Tube current: 30-40 mAs
• Dose: 1.08 mSv* (28 mGy.cm)

▶ Findings
A significant stenosis of the proximal part of the right pulmonary artery was discovered, together with a stenosis and anomaly of the right main bronchus. One significant aorto pulmonary collateral artery originated from the abdominal aorta at the level of the coeliac trunc. This collateral supports the lower lobe of the right lung. No other collaterals were depicted. The pulmonary veins are located properly. Confirmation of the ventricular septal defect together with an open arterial duct.

*Dose conversion with ICRP 0-year-old Chest factor of 0.039 * DLP
(Annals of the ICRP, Volume 37, Issue 1, March 2007)
The dynamic nature of cardiac CT allows for multi-faceted studies when CAD and myocardial diseases are studied simultaneously. With CardIQ Function Xpress, the all-in-one approach to full cardiac functional analysis is quick and straightforward.

**CardIQ Function Xpress**
- Fully automated software to perform functional studies of the heart!
  - Fast, accurate and automatic for a full cardiac diagnosis
  - Detection of all chambers on all phases and their volume analysis
  - Left Ventricle, Right Ventricle and Right Atrium ejection fraction
  - Myocardial wall analysis

**CASE**

Dr. Roobottom and Dr. Morgan-Hughes • University Plymouth • Derriford, UK

- **Patient History**
  Young male patient presented chest pain. Transthoracic echocardiography demonstrated asymmetrical septal hypertrophy with septal and anteroseptal wall thickening at the level of the papillary muscles of 2.2 cm with no detectable outflow gradient at rest. Coronary CTA was used so as to determine if there was any co-existing coronary artery disease.

- **Technique**
  Scanner: LightSpeed VCT
  - Acquisition mode: SnapShot Segment
  All cardiac phases were reconstructed. Preprocessing and preloading of all phases was used to speed up interpretation

- **Findings**
  **Ejection Fraction Analysis**
  The Automatic Ejection Fraction feature identifies and measures the left ventricular (LV) volumes in both end systoles and end diastole (ES, ED). The ES volume (35%) was 52 ml and the ED Volume (85%) was 182 ml. The resultant ejection fraction was 71%.

  **Myocardium Analysis**
  The myocardial analysis protocol contours the endocardial and epicardial contours and allows for “bull’s eye” displays of wall thickness, wall motion and wall thickening, and cine mode. These demonstrate the increased septal thickness, septal hypokinesis and decreased contractility associated with hypertrophic cardio-myopathy (HCM). These findings support the echocardiographic findings in the diagnosis of HCM.

Demonstrates endocontour automated analysis of the LV in end-diastolic (a) and in end-systolic (c), and corresponding 3D volume of LV (b, d). From this data the ejection fraction and volumes are derived (e).
Cardiac CT scanning has become a standard for the treatment planning of ablation procedures of the pulmonary veins. This technique provides electrophysiologists additional anatomical information important to optimize complex ablation procedures.

**CardEP**

Image analysis application dedicated to Electrophysiology Planning
- Pre-procedural EP planning and mapping
- Left Atrium and Pulmonary Vein assessment before ablation procedures
- Coronary sinus visualization before lead placement
- Gauge your catheter size with vessel analysis for bi-ventricular lead placement

**Patient History**
Young man has a previous history of abnormal atrial fibrillations and wishes to reduce medication doses. CT scan is recommended for exploration of pulmonary veins for ablation procedure.

**Technique**
- Scanner: LightSpeed VCT
- Acquisition mode: SnapShot Pulse prospective ECG-gating and ASiR reconstruction.
- Tube Voltage: 100 kVp
- Tube Current: 350 mA
- Coverage: 140 mm
- Average HR: 55 BPM
- Dose: 1.0 mSv* (DLP = 72 mGy·cm)

**Findings**
The CT exam was used to confirm that all of the pulmonary vein cavities were of normal caliber, with the left atrium measuring 95.8 cm³ and the left auricle 6.4 cm³. Aside from the pulmonary vein study, the patient’s coronary arteries were found to be normal with no traces of significant stenoses or plaques.

Obtained by ICRP using a chest factor of 0.014DLP*

Left atrium with a volume of 95.8 cm³
Left auricle with volume of 6.4 cm³

3D build of the coronary tree
VR rendering of the pulmonary veins
Lumen view of left superior pulmonary vein
Peripheral Vascular CTA has become a routine tool to diagnose and prepare planning for less invasive endovascular therapies. VesselIQ Xpress allows the treating physician to extend interpretation of vascular exams thanks to automated vessel tracking.

**VesselIQ Xpress**

*Analyze vessel aspects within seconds*

- Automated detection of main vessels structures with automatic bone removal for quick visualization
- Automated size, stenosis and length measurements with two mouse-clicks

**CASE**

**Dr. Guidotti • Casa di Cura Pierangeli • Pescara, Italy**

**Patient History**
Rule out of peripheral vascular disease.

**Technique**
- **Scanner**: Optima CT660
- **Acquisition Mode**: Helical mode
- **Tube Voltage**: 100 kVp
- **Tube Current**: mA Modulation
- **Dose**: DLP 700 mGy.cm

**Findings**
Right Posterior Tibial Artery is occluded (in the medium part of the artery) with rehabilitation of this artery in its distal part due to collateral circulation with interbone artery.

Sub-millimeter slice acquisition enables optimized visualization and study of distal vessels. VesselIQ performs fast bone and calcification removal for fast diagnosis.
**Case**

### Dr. Cederlund • Karolinska University Hospital, Huddinge • Stockholm, Sweden

- **Patient History**
  Female patient, smoker with hypertony, was turned in to the emergency department after episodes of atrial fibrillation. Ultrasound showed a 10x10mm aneurysm at the sinus vasa vasorum. Ascending aorta slightly dilated, but difficult to examine. Patient has no symptoms of angina. The aim of the CT was pre-operative evaluation of the thoracic aorta, the sinus vasa vasorum and the coronary arteries.

- **Technique**
  - **Scanner:** LightSpeed VCT
  - **Acquisition Mode:** SnapShot Pulse
  - **Average HR:** 56 BPM
  - **Tube Voltage:** 120 kVp
  - **Tube Current:** 400 mA
  - **Dose:** 3.6 mSv* (DLP= 240 mGy.cm)

- **Findings**
  Thoracic aorta is overall slightly widened. Diameters: ascending 41 mm, descending 33-23 mm. No thrombus or signs of dissection. Aneurysm of the right coronary cusp. Calcified and non-calcified plaques in both LAD and RCA with no significant narrowing of the lumen.

**CT imaging of the aorta and the valve prosthesis adds to the findings provided by pre-operative angiography and transthoracic echocardiography.**

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### Dr. Dacher • Centre Hospitalier Universitaire de Rouen • Rouen, France

- **Patient History**
  Female patient was referred to our institution for treatment of severe aortic stenosis. She was contra-indicated for conventional surgery. She underwent a successful percutaneous replacement of her aortic valve 3 days before the MDCT examination (Edwards Sapien #23). No postoperative aortic regurgitation was shown by transthoracic echocardiography. Clinical improvement was immediately observed after the procedure.

- **Technique**
  - **Scanner:** Discovery CT750 HD
  - **Acquisition Mode:** SnapShot Segment
  - **Average HR:** 45 BPM
  - **Tube Voltage:** 100 kVp
  - **Tube Current:** 200-548 mA

- **Findings**
  Cardiac CT is able to show the circularity of the stent graft and its relationships with the coronary ostia, the interventricular septum and the mitral valve (anterior leaflet).

  Due to the helical acquisition, dose for this case is higher with SnapShot Pulse.

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Obtained by ICRP using a chest factor of 0.014DLP*
Complete anatomical and functional assessment

Anatomical assessment completed by functional imaging provides detailed analysis of the impact of stenosis.

Case

Dr. Kaufmann, Dr. Herzog, Dr. Buechel • University Hospital Zurich, Switzerland

Patient History
Young male patient was referred with typical and partially atypical chest pain, non significant ST-depression (< 1mm in V5 & V6) at stress, normal echocardiography. Risk factors are: Smoker and dyslipidemia.

Technique
SPECT:
- Scanner: Discovery NM530c
- Stress 3 min - Rest 2 min
- Scanner: LightSpeed VCT
- Acquisition Mode: Snapshot Pulse
- Tube Voltage: 100 kVp
- Tube Current: 650 mA
- CT Dose: 1.9 mSv* (135 mGy.cm)

Findings
Tight lesion in the circumflex without calcification.
In view of the atypical clinical and negative stress ECG, a Myocardium Perfusion Imaging was performed. Tight circumflex lesion causing large ischemia. The Myocardium seems also jeopardized at rest. Accelerated referral to the cathlab for Percutaneous Coronary Intervention

CardIQ Fusion

An application dedicated to CT Cardiac fusion.
- Comprehensive visualization capabilities: visual assessment of physiological information such as PET and SPECT perfusion
- Fusion of anatomical and physiological information

Being able to fuse distinct exam modalities into one permits greater diagnostic insight. CardIQ Fusion merges the anatomic data of a CT scan with the perfusion data provided by molecular imaging.
Gemstone Spectral Imaging is a revolutionary feature that is exclusive to the Discovery CT750 HD. Today, it is expanding the information available for clinical diagnosis and workflow in two key areas: potentially enhancing the ability to characterize lesions through the separation of materials such as water, calcium and iodine and improving image quality with the spectral image.

**Gemstone Spectral Imaging**

*Advanced image analysis from fast kVp switching dual Energy*

- Monochromatic spectrums help separate materials
- Metal and dense material beam-hardening artifacts are dramatically reduced

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**Intervention planning**

Dr. Dacher • Centre Hospitalier Universitaire de Rouen • Rouen, France

**Patient History**

CT angio examination in standard helical mode was performed on a patient with hip prosthesis prior to percutaneous aortic valve implantation. Artefacts created from the hip implant prevented to correctly study the femoral arteries.

**Technique**

Scanner: Discovery CT750 HD

- Tube Voltage: fast kVp switching 80/140 kVp
- Acquisition Mode: Gemstone Spectral Imaging (GSI)
- Tube Current: 320 mAs

**Findings**

Acquisition in GSI mode with Metal Artifact Reduction (MARs) postprocessing, allowed for detailed analysis of stenosis and calcifications of the femoral arteries on both sides. Clear guidance to treatment planning of femoral vascular access can be delivered despite the prosthesis.

**CASE**

GSI with Metal Artifact Reduction (MARs) allows detailed vascular analysis which can be compromised in standard CT imaging.

GSI acquisition with MARs of the femoral artery. VR showing the hip prosthesis and a detailed visualization at 70keV monochromatic imaging.
Intervention follow-up

**Dr. Dacher • Centre Hospitalier Universitaire de Rouen • Rouen, France**

**Patient History**
Patient is referred for a control of an abdominal aortic aneurysm.

**Technique**
- Scanner: Discovery CT750 HD
- Acquisition Mode: Gemstone Spectral imaging
- Tube Voltage: fast KVp switching 80/140 kVp
- Tube Current: 300 mAs

**Findings**
An hyperdensity was detected in the aneurysm, the Material decomposition images allowed to characterize this hyperdensity as a calcification versus an endoleak.

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**Embolization follow-up**

**Dr. Soblayrolles • Centre Cardiologique du Nord • St. Denis, France**

**Patient History**
Control after splenic aneurysm embolization.

**Technique**
- Scanner: Discovery CT750 HD
- Acquisition Mode: Gemstone Spectral imaging
- Tube Voltage: fast KVp switching 80/140 kVp
- Tube Current: 300 mAs

**Findings**
The GSI follow up exam obtained after embolization of the aneurysms sac.

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GSI acquisition enables to obtain Material Decomposition images allowing advanced analysis of potential endoleaks.

**CASE**

**Axial VR without MARs**

**Iodine (calcium) images**
- 70 keV monochromatic images
- Attenuation Curves of Calcium and Iodine showing different attenuation at higher keV values

**Axial VR with MARs**

**Calcium Iodine images**

**Axial MIP without MARs**

**Axial MIP with MARs**
About GE Healthcare

GE Healthcare provides transformational medical technologies and services that are shaping a new age of patient care. Our broad expertise in medical imaging and information technologies, medical diagnostics, patient monitoring systems, drug discovery, biopharmaceutical manufacturing technologies, performance improvement and performance solutions services help our customers to deliver better care to more people around the world at a lower cost. In addition, we partner with healthcare leaders, striving to leverage the global policy change necessary to implement a successful shift to sustainable healthcare systems.

Our “healthymagination” vision for the future invites the world to join us on our journey as we continuously develop innovations focused on reducing costs, increasing access and improving quality around the world. Headquartered in the United Kingdom, GE Healthcare is a unit of General Electric Company (NYSE: GE). Worldwide, GE Healthcare employees are committed to serving healthcare professionals and their patients in more than 100 countries. For more information about GE Healthcare, visit our website at www.gehealthcare.com.

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