Auto Prescription

Unlocking Your Scanner's Full Potential Through Streamlined Workflow and Personalized Scanning

TECHNICAL WHITE PAPER

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Contents

Introduction

Auto-adjustment of kV, Noise Index, dose, and other scan settings based on patient size and clinical intent that:

- Provides balanced dose and image quality
- Facilitates low kV and low dose imaging where appropriate
- Allows faster scans for smaller patients and higher mAs for larger patients
- Enables increased throughput and consistency by reducing scan time adjustments
- Eliminates the need for size-based protocols
- Simplifies protocoling through re-usable, customizable profiles

Ultimately, this assures that the right scan settings, dose, and image quality are used for every patient, every time.

Today's Clinical Challenges & the Need for Auto Prescription

One of the more challenging aspects in radiology is choosing the optimal scan settings for a computed tomography (CT) exam that will result in diagnostically acceptable image quality at an appropriate dose level across an entire patient size population. Assuring that each scan setting is appropriately set based on the patient size may necessitate multiple size-based protocols or manual adjustments at scan time, both of which can lead to cumbersome workflow and undesirable variability in dose and image quality.

Auto Prescription is a new feature that enhances the CT user and patient experience in **two key areas**:

1. Balancing dose and image quality across all patient sizes and clinical intents by automatically selecting scan settings and optimizing Noise Index (NI) and dose based on patient size
2. Improving workflow by eliminating size-based protocoling, simplifying technologists' protocol selection, and reducing scan time adjustments and variability

In this paper, we will discuss what Auto Prescription is, how it's used, and how it can benefit your clinical practice and patient care.

What is Auto Prescription?

Overview

Auto Prescription is a profile-driven feature that automatically selects kV, pitch, rotation time, and other scan settings based on patient size, as well as optimizes the Prescribed Noise Index and WW/WL.

Users can enable Auto Prescription for any group in a protocol and select an Auto Prescription Profile appropriate for the clinical intent. Users can choose from a variety of GE Reference Profiles or create their own customized User Profiles tailored to their dose, image quality, and other system behavior preferences. At scan time, Auto Prescription determines the patient size from the scout image and then automatically applies the kV and other size-dependent scan settings, such as pitch and rotation time, from the profile. Auto Prescription then optimizes the Prescribed Noise Index and WW/WL based on the kV, Clinical Task, and Size-Adjusted Noise Index (SANI) strength settings from the profile. For users that do not want the system to automatically optimize the Prescribed Noise Index, custom User Profiles can be set up to use a specified Noise Index for each patient size range and kV.

Figure 1 is a high-level illustration showing how Auto Prescription optimizes scan settings to achieve optimal dose and image quality across patient sizes.

Figure 2 and *Figure 3* further summarize Auto Prescription Profiles, how they are used in Protocol Management, and how Auto Prescription works at scan time.

System calculates patient size from scout.

System selects kV, pitch, rotation time, and other settings from Auto Prescription Profile based on patient size. System optimizes Noise Index/dose based on selected kV, Clinical Task, Size-Adjusted Noise Index, and Patient Size.

Desired image quality and dose achieved for each clinical intent and patient size.

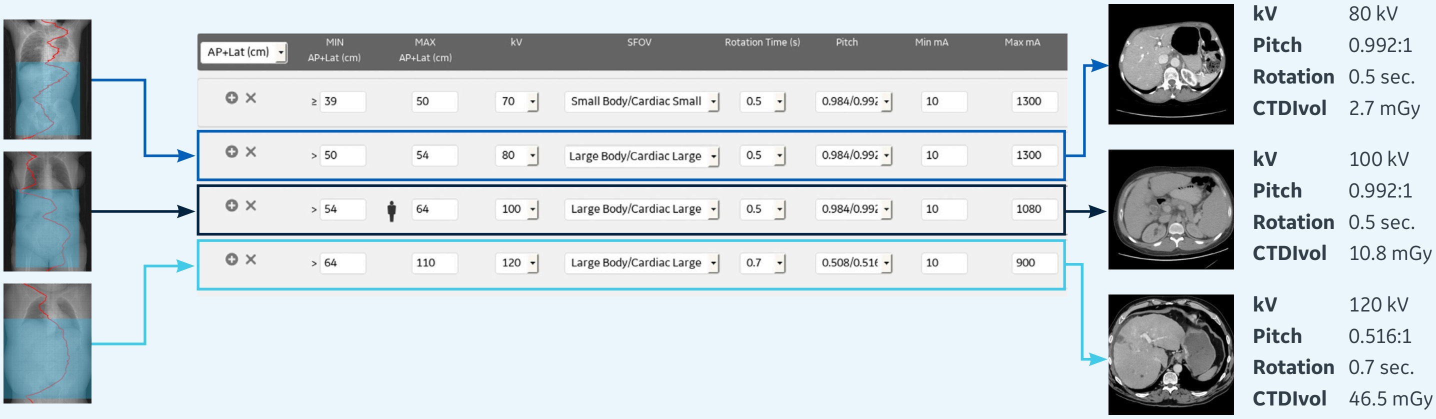


Figure 1. Auto Prescription Overview.

Auto Prescription Profiles

- Specify kV, pitch, rotation time, and other scan settings per patient size, as well as clinical task and size-adjusted Noise Index strength
- GE Reference Profiles balance dose and image quality across patient sizes for a wide variety of indications
- Create User Profiles tuned to desired system behavior preferences across patient size and clinical intent, such as reducing kV or dose or increasing scan speed

Protocol Management

- For any group in a protocol, enable Auto Prescription and then select the profile that is most appropriate for the clinical intent of that group (many GE Reference Protocols are already set up to use Auto Prescription with GE Reference Profiles)
- Set the Reference Noise Index appropriate for the Reference kV, Reference patient size, and clinical intent
- A single profile can be used in many protocols, thus simplifying protocol management and enabling consistent scan time results

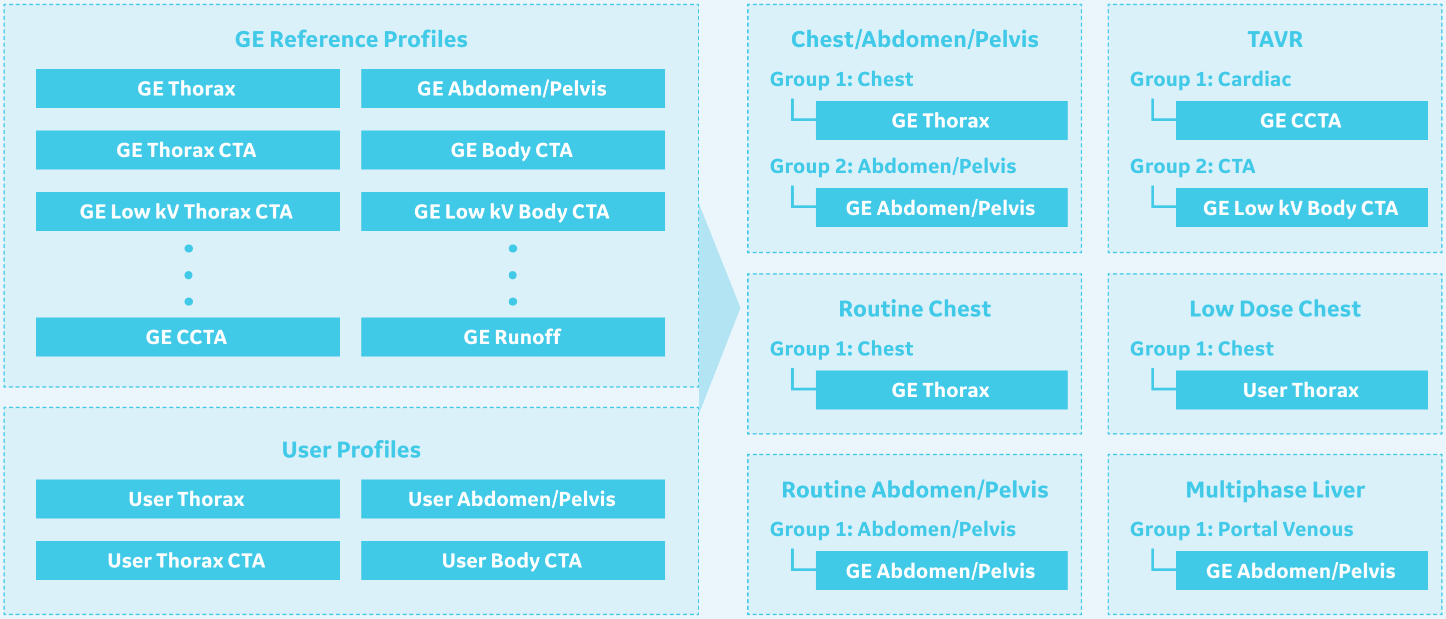


Figure 2. Auto Prescription Profiles and how they are used in protocols.

Scan Time

1. User selects a protocol with Auto Prescription enabled for one or more groups
   - Auto Prescription Profile
   - Reference kV and Noise Index
   - Reference WW/WL
2. User scans the scout
   - Patient size is automatically calculated
3. Auto Prescription determines which patient size range from the selected profile this patient falls within and then automatically...
   - Selects the kV and other scan settings for that size range from the profile and applies them to the scan prescription
   - Optimizes Noise Index based on clinical task and Size-Adjusted Noise Index strength from the profile
   - Optimizes WW/WL based on kV, Noise Index and Clinical Task

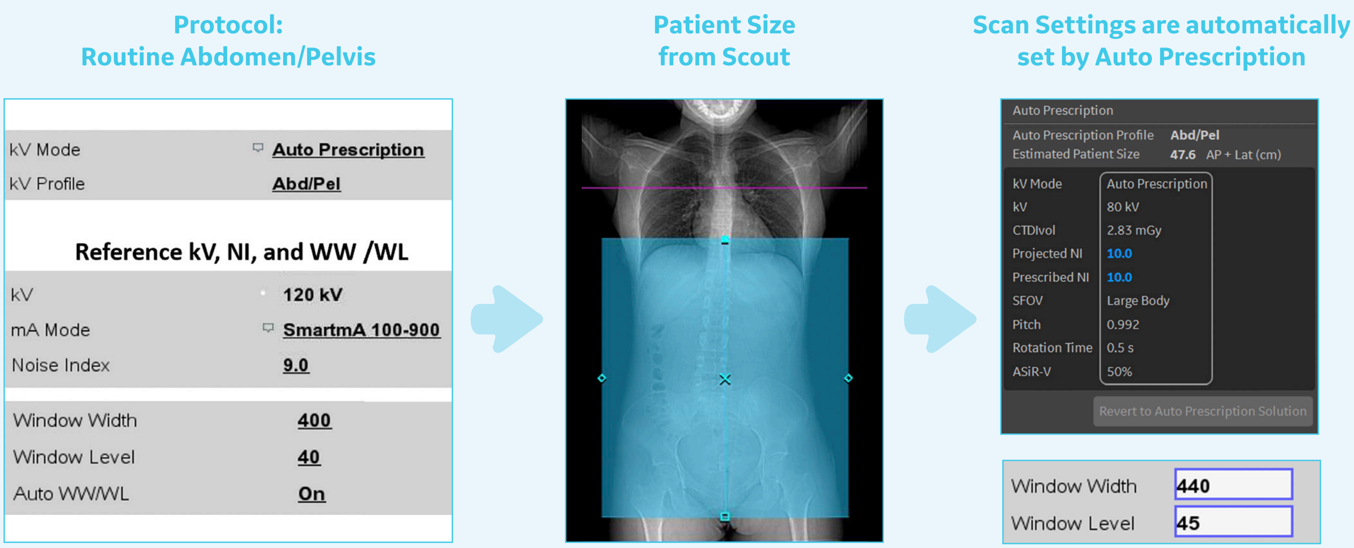


Figure 3. How Auto Prescription works at scan time.

What are Auto Prescription Profiles?

Overview

An Auto Prescription Profile specifies kV, pitch, rotation time, and other scan settings per patient size range, as well as Clinical Task and SANI strength *(Figure 4)*.

GE Reference Profiles come pre-loaded onto the CT scanner and are designed to provide balanced dose and image quality across patient sizes for a variety of clinical indications. The GE Reference Profiles are discussed in more detail in the GE Reference Profiles section.

By using the Auto Prescription Profile Editor, users can also create custom User Profiles tailored to their system behavior preferences across patient size and clinical intent, such as reducing kV or dose or increasing scan speed. For users that do not want the system to automatically optimize the Prescribed NI, User Profiles can be set up to use a specified NI for each patient size range and kV *(Figure 5)*.

Viewing and editing Auto Prescription Profiles, as well as enabling Auto Prescription in a protocol, is typically performed by a Medical Physicist or Lead Technologist. It is important to note that the Auto Prescription Profile Editor (*Figure 4* and *Figure 5)* is not shown during scan time.

Figure 4. Example Auto Prescription Profile showing various scan settings set per patient size range. In this profile, the option to set the Noise Index in the Protocol means that the Noise Index will be adjusted at scan time based on the selected kV, patient size, clinical task, and Size-Adjusted Noise Index strength set in the profile.

Figure 5. Example Auto Prescription Profile showing various scan settings set per patient size range. In this profile, the option to set the Noise Index in the Profile means that the user can specify the Prescribed Noise Index for each Patient Size Range. At scan time, the system will use the specified Noise Index from the Profile without making any additional adjustments.

Patient Size

Auto Prescription Profiles contain one or more size ranges. Size ranges consist of minimum and maximum size limits that can be specified in the following units:

- Dw (water equivalent diameter in cm)
- AP (Anterior Posterior measurement in cm)
- LAT (Lateral measurement in cm)
- AP + LAT (Anterior Posterior plus Lateral measurement in cm)

The profile must contain a size range that includes the Reference Patient Size, which is 58 cm AP + LAT (approximately 75 kg). The Reference Patient Size is used as a reference point by Auto Prescription when determining how to optimize the Prescribed Noise Index across kV and patient size.

At scan time, an estimate of the patient size over the scan range is calculated from the patient attenuation data of the scout. The attenuation information used is in units of Dw, which is then converted to the Patient Size Metric defined in the selected Auto Prescription profile to determine which size range from the profile the patient falls within.

The conversion from Dw to other Patient Size Metrics is based on work from previous studies[1-4] that analyzed phantom and clinical datasets and derived formulas to convert between Dw and AP + Lat, AP, Lat, weight, and BMI. In general, AP + Lat has a strong correlation to Dw, and so AP + Lat is the default Patient Size Metric used in the GE Reference Profiles (Note: AP + Lat is approximately twice the Dw). While not as strongly correlated to Dw, Lat may be appropriate for chest or cardiac scans. BMI and weight, on the other hand, are generally poor correlates for patient attenuation. Therefore, while the user can set up a profile in Weight or BMI, they must switch to another Patient Size Metric before being able to save the profile. When switching from one Patient Size Metric to another, all size values in the profile will automatically convert to the newly selected Patient Size Metric.

Reference Noise Index and Reference kV

For Auto Prescription to optimize the Prescribed Noise Index at scan time for the selected kV and patient size, it must start with a reference point of image quality. This reference point is known as the "Reference Noise Index."

The Reference Noise Index is the NI set in the protocol for the Reference kV.

The Reference kV is automatically set based on the Auto Prescription Profile. It is the kV that is set for the Patient Size Range under which the Reference Patient Size (58 cm AP + LAT) falls within.

At scan time, Auto Prescription will use the Reference Noise Index, Reference kV, and Reference Patient Size to determine the Prescribed Noise Index that should be used for the current patient size and for the selected kV, Clinical Task, and SANI from the Auto Prescription Profile.

Clinical Task

The Clinical Task determines how much to adjust the NI at the kV selected by Auto Prescription to maintain the same contrast-to-noise ratio (CNR) as the Reference kV and Reference Noise Index.

Clinical Tasks containing bone or iodine produce relatively larger increases in image contrast at lower kVs, so they can sustain relatively higher increases in noise, thereby offering more potential for radiation dose savings than a clinical task without iodine enhancement.

Size-Adjusted Noise Index

Size-Adjusted Noise Index (SANI) is a new feature introduced with Auto Prescription that automatically adjusts the Prescribed Noise Index based on patient size to allow users to better tailor noise and dose levels to their preference.[5] Specifically, SANI increases Prescribed Noise Index for larger patients and decreases Prescribed Noise Index for smaller patients. This adjustment to the NI is in addition to the adjustment in NI based on the selected kV and Clinical Task (described in the previous section).

Radiologists may be willing to accept more noise in larger patients for two reasons:

1. More visceral fat in larger patients may lead to more inherent contrast between organs, resulting in a higher CNR
2. Dose may be higher than desired if using the same NI for a large patient that would be used for a smaller patient

Conversely, there may be a desire to decrease noise in smaller patients:

1. Less visceral fat in smaller patients may lead to less inherent contrast between organs, resulting in a lower CNR
2. Dose may be lower than desired if using the same NI for a small patient that would be used for a larger patient

With SANI, users can select one of several strength settings both below and above the Reference Patient Size. *Figure 6* shows the estimated relative decrease or increase in NI across patient size for each SANI strength setting relative to using a constant Noise Index. At scan time, SANI adjusts the Reference Noise Index set in the protocol based on the patient size calculated from the scout. To prevent dose from going too high (for smaller patients) or too low (for larger patients), SANI imposes a maximum limit on the amount of relative decrease or increase to the NI.

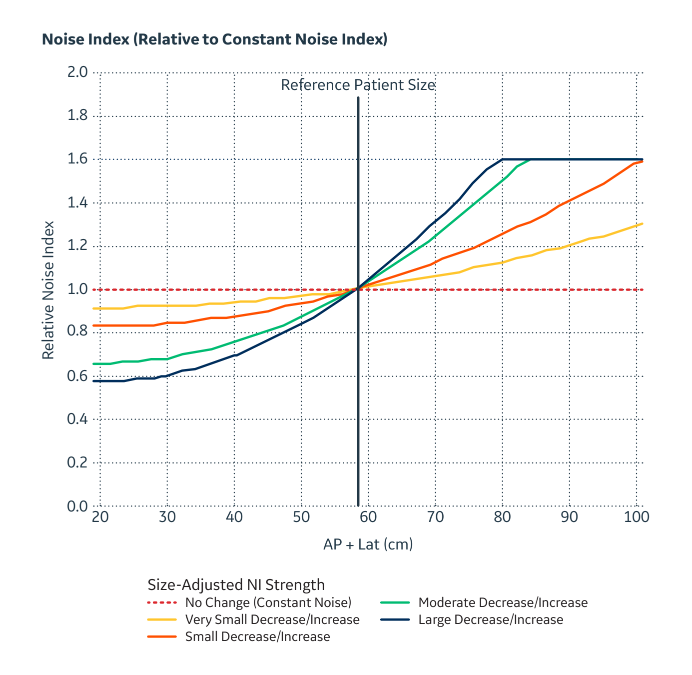


Figure 6. Estimated change in Prescribed Noise Index by Patient Size for each SANI Strength.

Size-Adjusted Noise Index *(continued)*

Figure 7 shows the estimated relative decrease or increase in CTDIvol across patient size for each SANI strength relative to the Reference Patient Size. This figure shows estimated relative CTDIvol for the fixed scan settings of 120 kV, 9 NI, 5 mm slice thickness, 80 mm detector coverage, 0.992:1 pitch, and 0.5 sec. rotation time.

Figure 8 shows estimated relative CTDIvol for the same fixed scan settings as in *Figure 7*, except with 0.516:1 pitch, and 1.0 sec. rotation time to allow for additional mAs needed for larger patient sizes to achieve the Prescribed Noise Index.

Figure 7 and *Figure 8* provide an idea of the relative dose achieved when using SANI for a few example sets of scan settings. The actual relative increase or decrease in CTDIvol for a given patient size and SANI strength will vary based on the maximum achievable tube output at the kV, pitch, and rotation time setting for the Prescribed Noise Index and scan range being used at scan time.

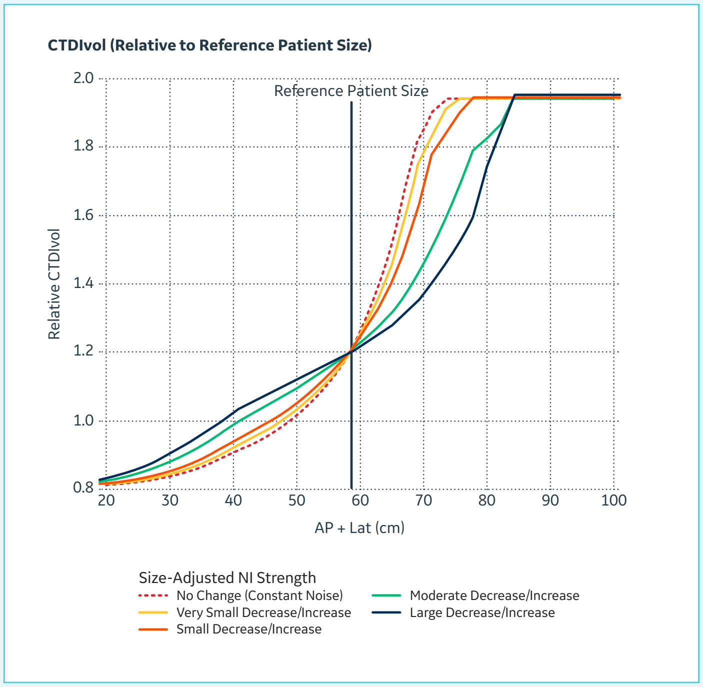


Figure 7. Estimated CTDIvol relative to Reference Patient Size (120 kV, 9 NI, 5 mm slice thickness, 80 mm/p0.992:1/0.5 sec. rotation). Note that the relative CTDIvol may change with varying scan prescription settings.

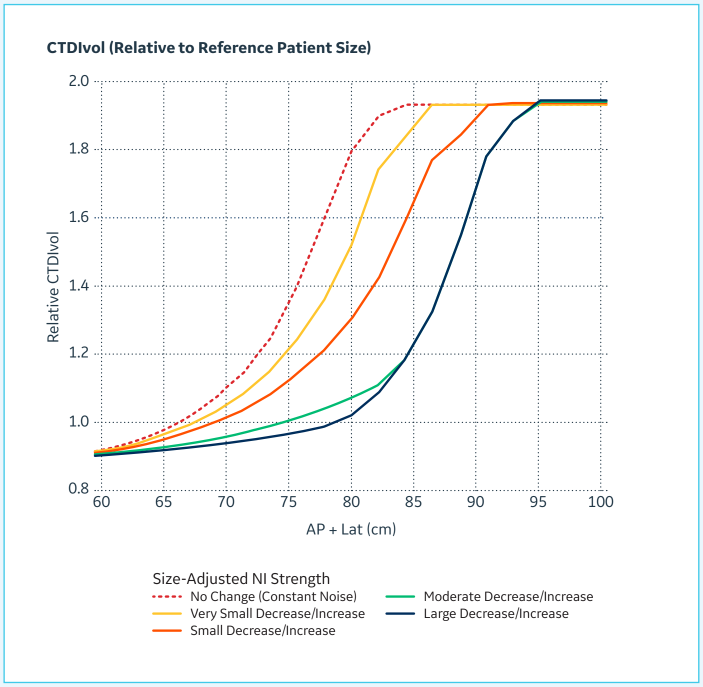


Figure 8. Estimated CTDIvol relative to Reference Patient Size (120 kV, 9 NI, 5 mm slice thickness, 80 mm/p0.516:1/1.0 sec. rotation). Note that the relative CTDIvol may change with varying scan prescription settings.

What is Auto WW/WL?

Auto WW/WL optimizes the WW and WL settings of an image acquired at a given kV and noise level to look similar to an image that would be acquired at the reference settings (Reference kV, Reference NI, and Reference WW/WL), as shown in *Figure 9*.

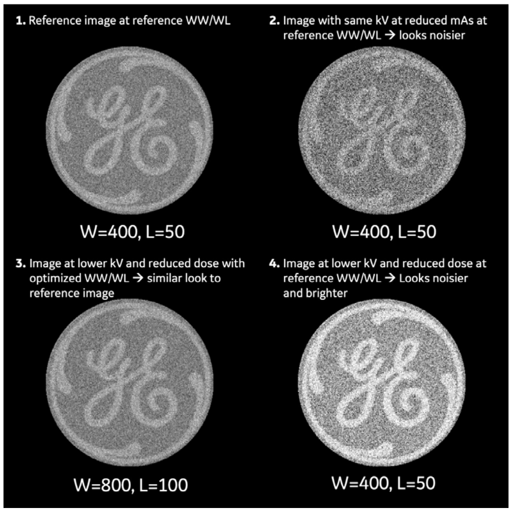


Figure 9. Auto WW/WL optimizes the WW and WL settings of an acquired image to look similar to a reference image.

How Do I Set Up a Protocol to Use Auto Prescription?

For any group in a protocol, users can enable Auto Prescription and then select the Auto Prescription Profile that is most appropriate for the clinical intent of that group. Many GE Reference Protocols are already set up to use Auto Prescription with GE Reference Profiles, and it is recommended that users start with these protocols.

Once an Auto Prescription Profile is selected, the kV is automatically set to the Reference kV of the profile (that is, the kV defined in the patient size range under which the Reference Patient Size falls within). The user should set a Reference Noise Index that is appropriate for the Reference kV, Reference Patient Size, and clinical intent.

To ensure that the WW/WL settings are automatically optimized at scan time, Auto WW/WL should be enabled, and a Reference WW/WL should be set that is appropriate for the Reference kV and Reference Noise Index.

How Does Auto Prescription Work at Scan Time?

After the user selects a protocol with Auto Prescription enabled and scans the scout image, Auto Prescription automatically calculates the patient size from the attenuation information of the scout over the prescribed scan range. Auto Prescription then determines which patient size range from the selected profile this patient falls within and then automatically selects the kV and other scan settings for that size range from the profile and applies them to the scan prescription. If the profile is configured to use a Reference Noise Index in the protocol, then Auto Prescription will optimize the Prescribed Noise Index for the selected kV and patient size based on Clinical Task and Size-Adjusted Noise Index strength from the profile, as well as optimize the WW/WL (if Auto WW/WL is enabled). If instead a NI is specified for each size range in the profile, then the NI from the profile will be used and the system will not make any further adjustments to it. Finally, the selected kV, NI, and other scan settings are used by Smart mA to determine the mA and dose required to meet the Prescribed Noise Index. *Figure 3* demonstrates the scan time workflow of Auto Prescription.

If the Scan Technologist overrides any of the scan parameters set by Auto Prescription, then the Auto Prescription Widget will show which settings changed as well as the impact to the NI and CTDIvol (*Figure 10*). The widget also provides the user an option to easily revert back to the Auto Prescription solution.

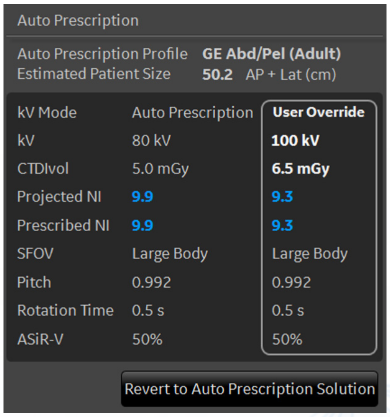


Figure 10. Auto Prescription Widget.

What are the Benefits of Auto Prescription?

Using Auto Prescription with GE Reference Profiles provides balanced dose and image quality across a wide range of clinical intents and patient sizes, reduces dose at lower kVs, and trades off between faster scan speed and higher mAs by automatically changing rotation time and pitch when appropriate. The concept of re-usable size-based profiles streamlines protocol management and eliminates the need for multiple size-based protocols. Finally, by automatically selecting scan settings and optimizing dose and image quality based on clinical intent and patient size, Auto Prescription reduces the need for scan time adjustments, thereby enhancing workflow, throughput, and consistency.

In the following sections, we will explore the underlying physics of low kV imaging and discuss how the Auto Prescription GE Reference Profiles are designed to provide balanced dose and image quality across patient size as well as to reduce radiation dose at low kVs.

The Physics of CT and Low kV Imaging

Background

X-ray attenuation is the fundamental physical process underlying CT imaging. The attenuation properties of a material are described by that material's energy-dependent mass attenuation coefficient. As x-ray energy decreases, the difference in the values of the mass attenuation coefficient between any two materials increases *(Figure 11)*.

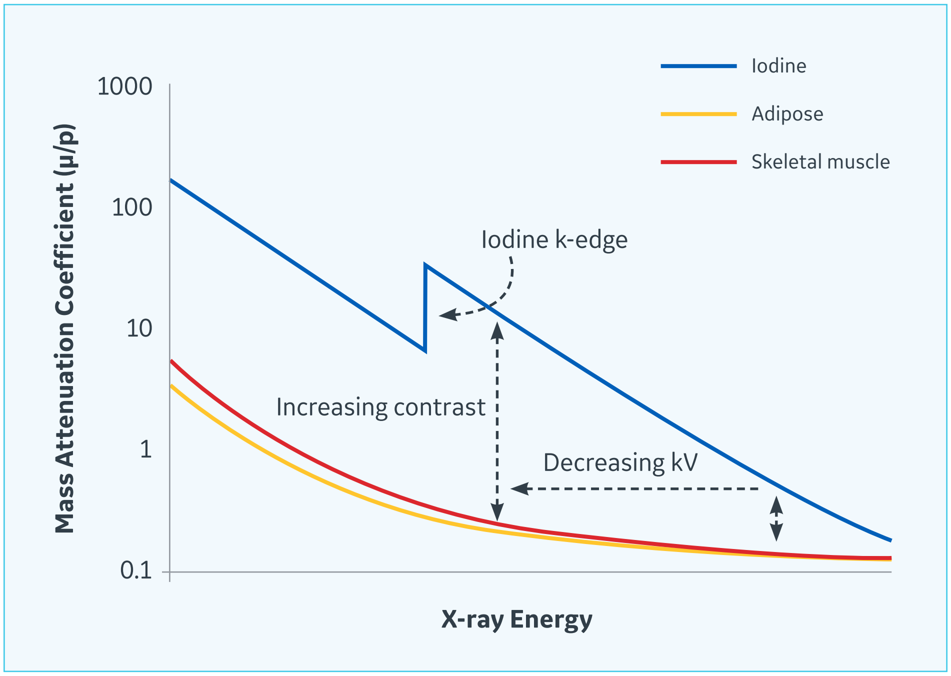


*Figure 11. Mass attenuation coefficients for adipose tissue (**yellow**), skeletal muscle (**red**), and iodine (**blue**) vs. x-ray source energy, plotted on log-log axes. The k-edge of iodine occurs around 33 keV. Data source: The National Institute of Standards and Technology (NIST).*

This physical phenomenon manifests in the reconstructed CT image as the relative difference in HU values seen between two materials; as the kV decreases, the image contrast, or Hounsfield Units (HU), between the two materials increases *(Figure 12)*. While this is generally true for any two materials in the diagnostic energy spectrum, the increased contrast is especially pronounced for iodine due to its high attenuation properties relative to other biological materials.

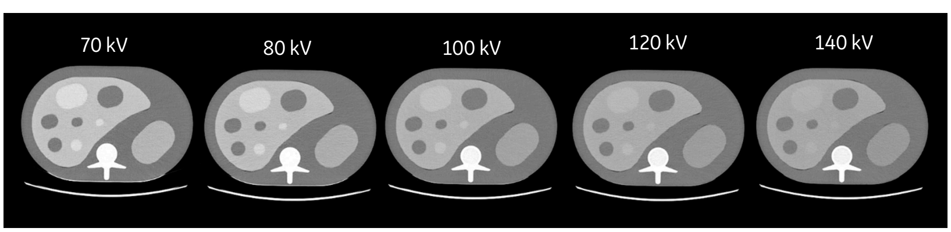


Figure 12. Scans of a liver phantom with simulated hypo- and hyper-dense (iodine-enhanced) lesions. As the kV decreases, the iodinated lesions appear brighter. All images were obtained with equal CTDIvol and have a WW/WL = 400/40.

What are the Potential Benefits of Low kV Imaging?

Ultimately, it is the relative increase in image contrast that enables potential benefits when scanning at low kV.[6,7] The three primary benefits of low kV imaging (and their assumptions) are:

1. Reduced radiation dose (assuming fixed contrast dose and fixed CNR)
2. Reduced contrast dose (assuming fixed radiation dose and fixed CNR)
3. Improved CNR (assuming fixed radiation dose and fixed contrast dose)

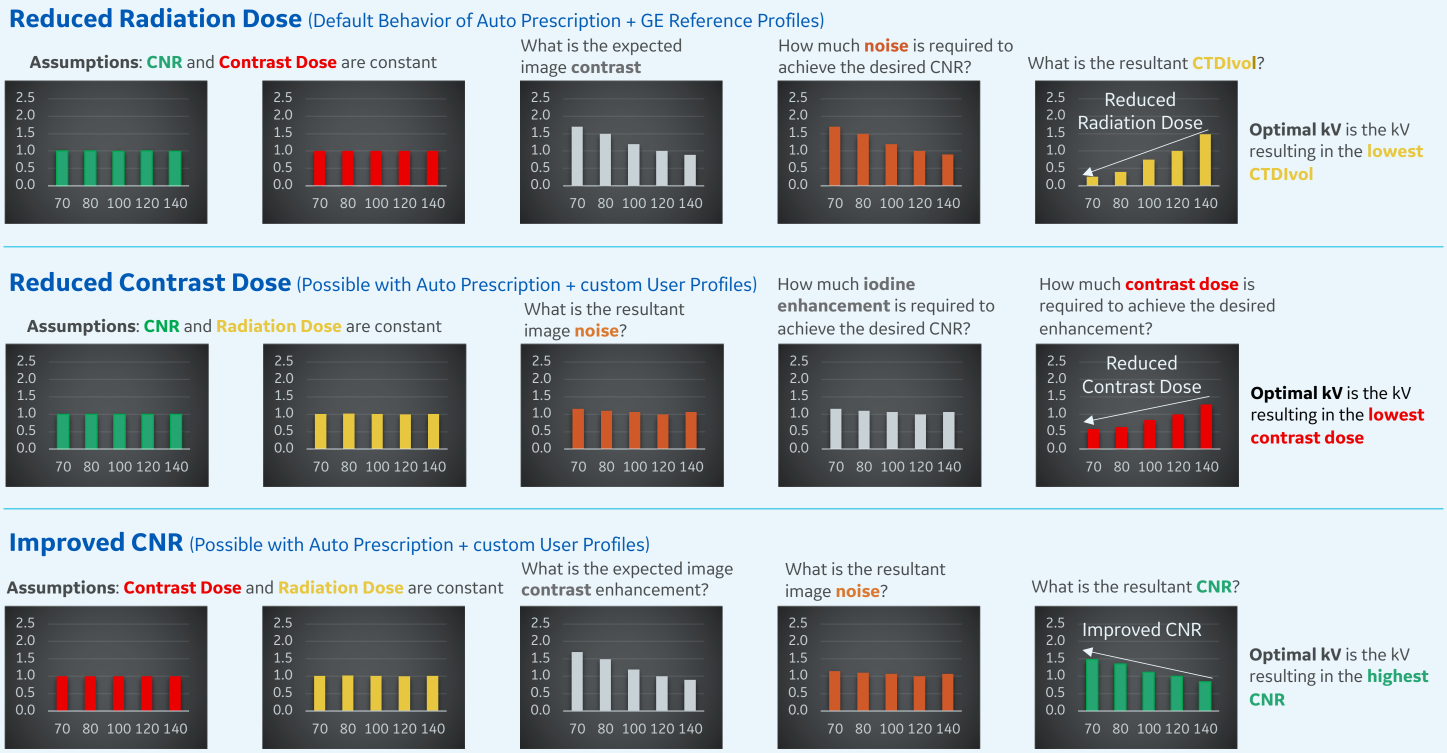


Figure 13. Example demonstrating the three main benefits of Low kV Imaging and their respective assumptions. GE Reference Profiles are designed to provide optimal image quality while reducing radiation dose at lower kVs. Custom User Profiles defined with NI in the profile can be designed in such a way as to reduce contrast dose or increase CNR as kV is reduced. In all scenarios, the optimal kV is dependent on the patient size and clinical task.

Figure 13 demonstrates how each of the three potential benefits of low kV imaging can be achieved. For each potential benefit, the underlying assumptions are different. Further, the optimal kV is defined differently and is highly dependent on the patient size, clinical task, and available tube power. For some patient sizes and clinical tasks, there may be no benefit to scanning at lower kVs and, in fact, it may be more beneficial to scan at higher kV. This is generally the case for very large patient sizes and/or low contrast imaging, as will be discussed in the following sections.

Auto Prescription used with GE Reference Profiles is designed to provide optimal image quality across the range of patient sizes and to reduce radiation dose at lower kVs (top row of *Figure 13*). This will be discussed in more detail below. Users can still create customized User Profiles in such a way as to reduce contrast dose or increase CNR as kV is reduced.

In the following sub-sections, we will explore how clinical task and patient size impact the amount of radiation dose savings that can be realized using low kV imaging. While not discussed in this paper, the clinical task and patient size similarly impact the amount of contrast dose savings or amount of CNR improvement that can be achieved at low kVs.

How Does Clinical Task Impact Low kV Imaging?

Clinical tasks involving relatively high contrast imaging, such as musculoskeletal and angiography studies, result in relatively larger increases in image contrast at lower kVs. As such, they allow for relatively higher increases in noise to maintain the same CNR as higher kVs, thereby offering more potential for radiation dose savings at lower kVs than clinical tasks without inherently high contrast or iodine enhancement. This phenomenon is illustrated in *Figure 14*.

Figure 14. The impact of clinical task on optimal kV for a given patient size, where optimal kV is the kV resulting in the lowest CTDIvol for a desired image quality, defined by CNR.

The following example shows how the clinical task impacts the Noise Index required at each kV to maintain an equivalent CNR to the reference kV, which in turn determines the CTDIvol required at each kV to meet their respective Prescribed Noise Index value. The kV with the lowest CTDIvol that can be achieved by the x-ray tube is considered the optimal kV.

Clinical Task: Soft Tissue Non-Contrast

kV	Noise Index	CTDIvol Change (%)
70	9.8	+38%
80	9.3	+35%
100	9.2	+22%
120	9.0	---
140	8.7	+26%

Clinical Task: Angiography

kV	Noise Index	CTDIvol Change (%)
70	13.9	-60%
80	12.2	-42%
100	10.5	-14%
120	9.0	---
140	7.8	61%

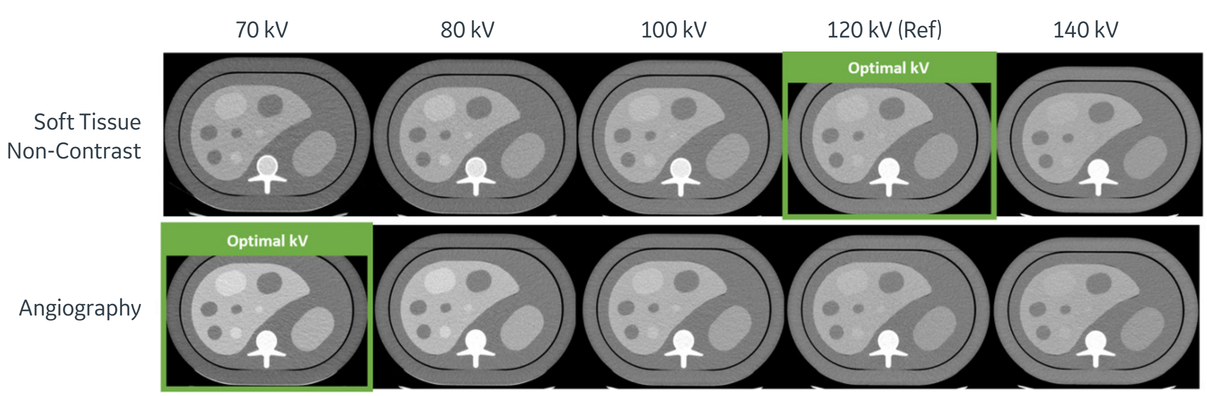
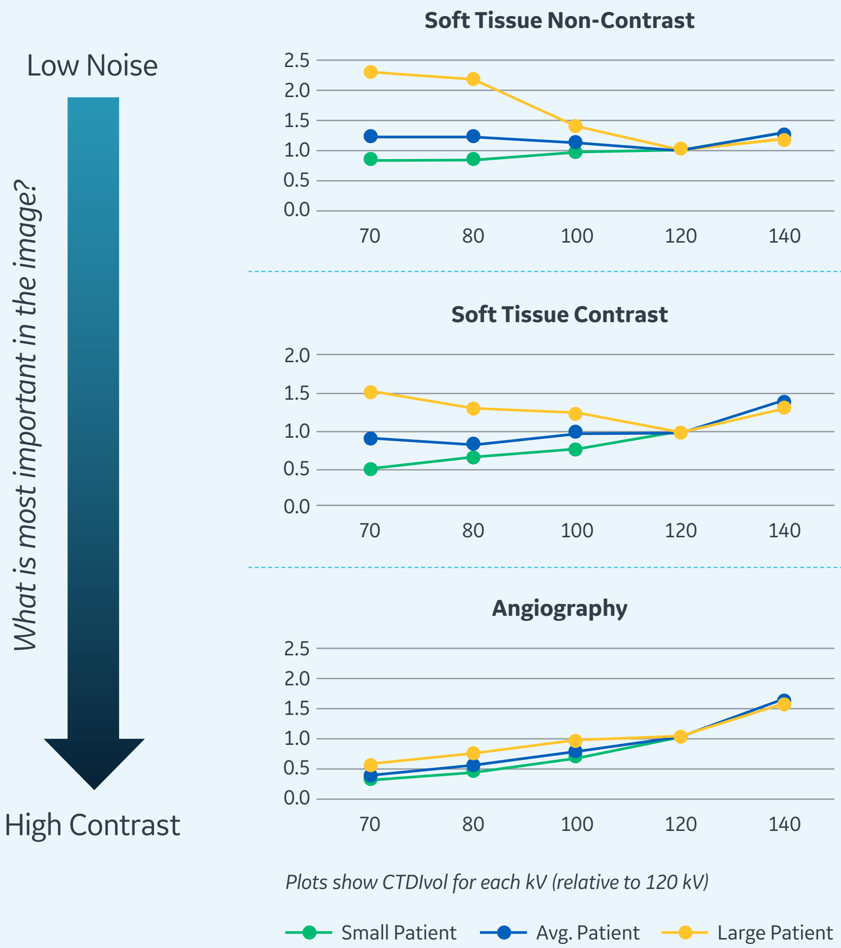


Figure 15. The impact of clinical task on optimal kV, where optimal kV is the kV resulting in the lowest CTDIvol for a desired image quality, defined by CNR. For each clinical task, WW/WL is varied by Auto WW/WL at each kV to maintain a similar look and feel to the Reference kV (120 kV).

How Does Patient Size Impact Low kV Imaging?

In addition to the clinical task, the patient size is also important in determining which kV may provide the lowest dose.



Soft Tissue Non-Contrast

Patient Size	Optimal kV (Lowest CTDIvol)
Small	70/80 kV
Average	100/120 kV
Large	120 kV

Soft Tissue Contrast

Patient Size	Optimal kV (Lowest CTDIvol)
Small	70 kV
Average	80 kV
Large	120 kV

Angiography

Patient Size	Optimal kV (Lowest CTDIvol)
Small	70 kV
Average	70 kV
Large	70 kV

Figure 16. Optimal kV is dependent both on clinical task and patient size. In this figure, the optimal kV for each patient size is the one with the lowest CTDIvol. Note that this figure does not consider tube power limitations. The actual optimal kV will also depend on which kV can achieve the Prescribed Noise Index.

The following example shows how patient size impacts the optimal kV for a Soft Tissue +C Low clinical task.

Patient Size: Small

kV	Noise Index	CTDIvol Change (%)
70	10.4	-21%
80	9.8	-11%
100	9.3	-2%
120	9.0	---
140	8.7	27%

Patient Size: Large

kV	Noise Index	CTDIvol Change (%)
70	10.3	14%
80	9.8	16%
100	9.3	19%
120	9.0	---
140	8.7	26%

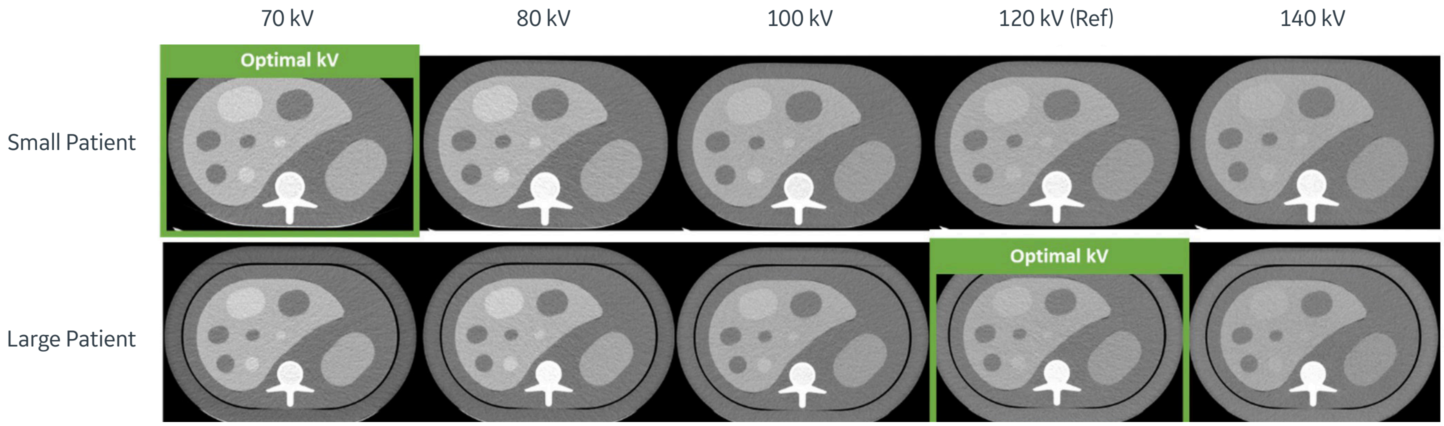


Figure 17. The impact of patient size on optimal kV, where optimal kV is the kV resulting in the lowest CTDIvol for a desired image quality, defined by CNR. For each clinical task, WW/WL is varied by Auto WW/WL at each kV to maintain a similar look and feel to the Reference kV (120 kV).

How Does Auto Prescription Facilitate Low kV Imaging?

Auto Prescription facilitates low kV imaging through use of the GE Reference Profiles. Each GE Reference Profile is specifically designed for a different clinical intent or exam type, such as Cardiac CTA, Routine Abdomen/Pelvis, Routine Chest, and Chest or Body CTA. When using Auto Prescription with GE Reference Profiles, lower kVs will be used when it is most appropriate to do so — in other words, when significant dose savings can be achieved without compromising image quality.

Alternatively, some users may choose to create their own custom User Profiles to use low kV imaging more often (e.g., for a wider range of clinical intents or patient sizes) than the GE Reference Profiles, or to achieve different goals at low kV (e.g., reduction in contrast agent or increase in CNR rather than a reduction in radiation dose). However, it is recommended that these types of changes only be made by a qualified individual or individuals who can assure the resultant image quality and dose levels will be appropriate across the patient size population.

Auto Prescription Profiles

GE Reference Profiles

GE Reference Profiles, which come pre-loaded onto the scanner, are tailored to the image quality needs of specific clinical indications and designed to provide balanced dose and image quality across patient sizes. The GE Reference Profiles vary kV with patient size to provide consistent image quality while reducing dose at lower kVs. They additionally vary rotation time and pitch to provide faster scan speeds for smaller to average-sized patients while providing higher mAs to maintain image quality for larger patients.

When first using Auto Prescription, it is recommended that users begin with the GE Reference Profiles.

Table 1 shows a sub-set of the GE Reference Profiles available on the Revolution Apex and the expected behaviors and benefits across different patient sizes. *Figure 17* and *Figure 18* compare the behavior of using Auto Prescription with GE Reference Profiles for Abdomen/Pelvis and Body CTA versus using conventional 120 kV protocols and highlight key behaviors and benefits of using Auto Prescription.

Table 1: *Examples of a sub-set of GE Reference Profiles for Revolution Apex*

Profile	Clinical Intent	Notable Profile Behaviors
GE Abdomen/ Pelvis	This profile is intended for use during Routine Abdomen/Pelvis scans for evaluation of abnormalities of abdominal and pelvic structures.	• Low kV for small patients reduces dose relative to fixed kV • Size-Adjusted Noise Index for large patients reduces dose relative to fixed NI • Decreased helical pitch and increased rotation time for very large patients to achieve appropriate image quality
GE Body CTA	This profile is intended for use during body CTA for evaluation of small abdominal vasculature.	• Low kV for small and medium-sized patients reduces dose relative to fixed kV • Size-Adjusted Noise Index for larger patients reduces dose relative to fixed NI • Constant helical pitch and increased rotation time for very large patients to achieve appropriate image quality with minimal impact to contrast timing
GE Low kV Body CTA	This profile is intended for use during body CTA for evaluation of abdominal aortic aneurysm and other large abdominal vasculature.	• Low kV for small, medium, and large patients reduces dose relative to fixed kV • Size-Adjusted Noise Index for larger patients reduces dose relative to fixed NI • Constant helical pitch and increased rotation time for very large patients to achieve appropriate image quality with minimal impact to contrast timing
GE Thorax	This profile is intended for use during Routine Thoracic scans for evaluation of chest region for abnormalities.	• Low kV for small and medium-sized patients reduces dose relative to fixed kV • Size-Adjusted Noise Index for larger patients reduces dose relative to fixed NI
GE Thoracic CTA	This profile is intended for use during Thoracic CTA scans for evaluation of small thoracic vasculature (e.g., Pulmonary Embolism).	• Low kV for small and medium-sized patients reduces dose relative to fixed kV • Size-Adjusted Noise Index for larger patients reduces dose relative to fixed NI • Constant helical pitch and increased rotation time for very large patients to achieve appropriate image quality with minimal impact to contrast timing
GE Low kV Thoracic CTA	This profile is intended for use during Thoracic CTA scans for evaluation of large thoracic vasculature (e.g., Thoracic Aorta).	• Low kV for small, medium, and large patients reduces dose relative to fixed kV • Size-Adjusted Noise Index for larger patients reduces dose relative to fixed NI • Constant helical pitch and increased rotation time for very large patients to achieve appropriate image quality with minimal impact to contrast timing
GE CCTA	This profile is intended for use during prospectively gated Cardiac axial scans for evaluation of coronary arteries.	• Low kV for small and medium patients reduces dose relative to fixed kV
GE CAP (Pediatric)	This profile is intended for use during routine pediatric Chest, Abdomen and Pelvis scans for evaluation of abnormalities of abdominal, pelvic, and thoracic structures.	• Low kV across pediatric size range reduces dose relative to fixed kV • High pitch and fast rotation times to minimize scan motion

Routine Abdomen/Pelvis

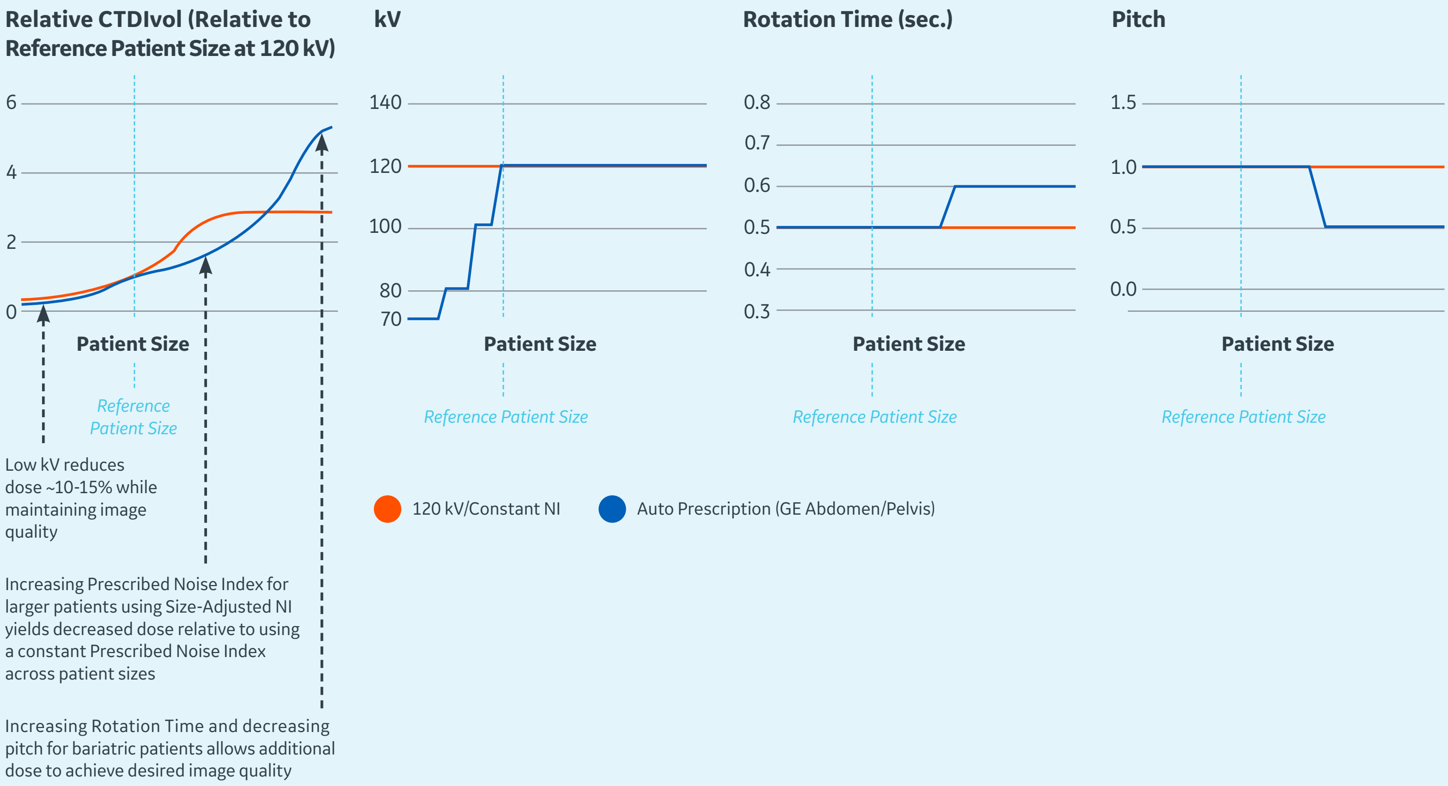


Figure 18. Comparison of routine Abdomen/Pelvis protocol using 120 kV at fixed Noise Index versus routine Abdomen/Pelvis protocol using Auto Prescription with GE Abdomen/Pelvis profile.

Body CT Angiography

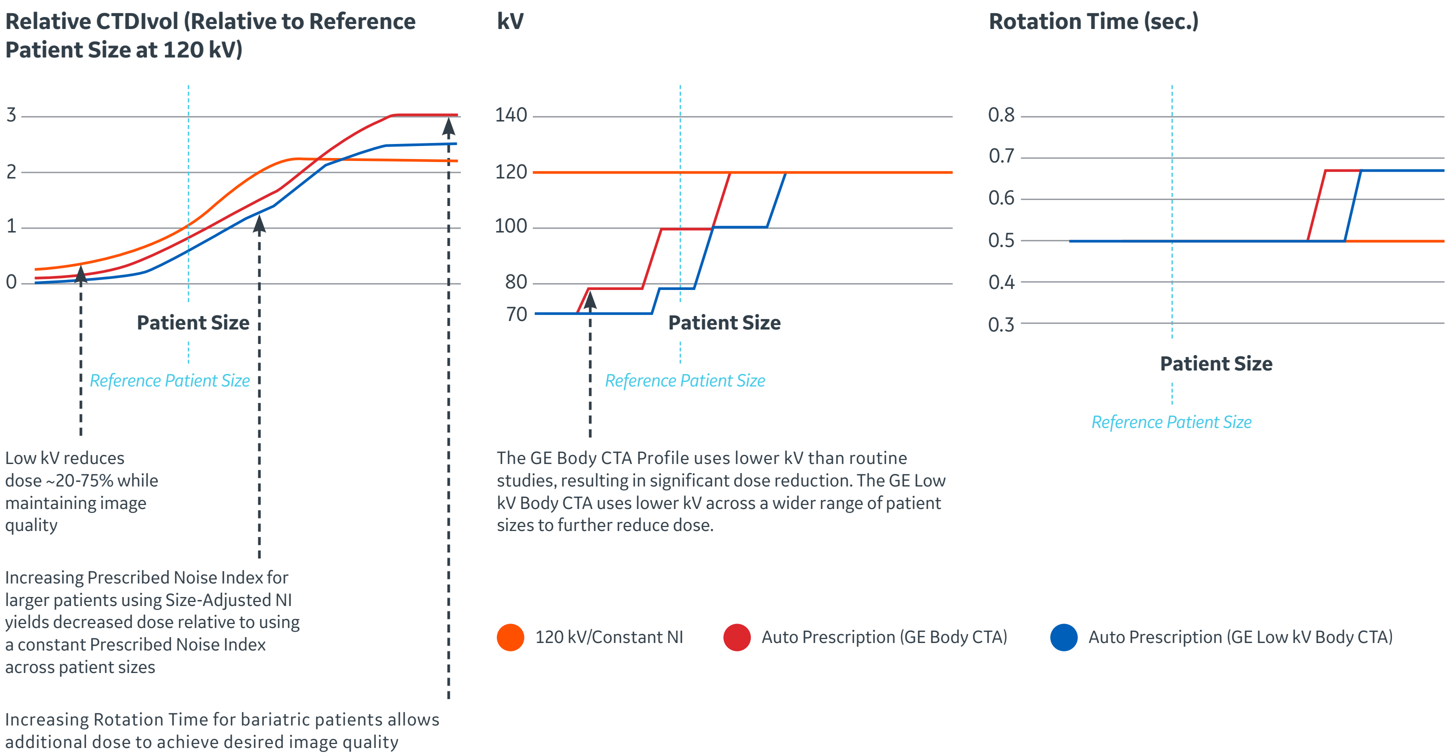


Figure 19. Comparison of Body CTA protocol using 120 kV at fixed Noise Index versus Body CTA Protocol using Auto Prescription with GE Body CTA profile and GE Low kV Body CTA profile.

User Profiles

While customers are encouraged to use Auto Prescription with GE Reference Profiles, some may choose to create custom User Profiles to tailor the system behavior to their preferences. For example, some users may want to use low kV imaging more often (e.g., for a wider range of patient sizes), achieve different goals at low kV (e.g., reduction in contrast agent or increase in CNR rather than a reduction in radiation dose), maximize scan speed for a certain clinical intent, or adjust the noise and dose levels differently across patient sizes.

While the Auto Prescription Profile Editor makes it easy to create User Profiles, it is recommended that such changes only be made by a qualified individual or individuals who can assure that the resultant image quality and dose levels will be appropriate across the patient size population.

Clinical Evidence

Several customers are already realizing the benefits of Auto Prescription on both the Revolution CT and Revolution Apex. The following sections highlight the experience of two clinical sites that used Auto Prescription to improve workflow and increase their use of low kV imaging to reduce dose. Note that the results presented for these two case studies are based on data collected from each site using their specific protocols.

Clinical Site #1: Revolution Apex

The following case study illustrates some of the clinical benefits realized with Auto Prescription. The institution was equipped with three GE Revolution scanners: two Revolution CT systems and one Revolution Apex. The Revolution Apex system used Auto Prescription, while the two Revolution CT systems did not. Data was collected for each scanner over a one-year period.

For the first several weeks of use, Auto Prescription was used with GE Reference Profiles. After image quality and dose levels were reviewed and deemed acceptable, the institution decided to create User Profiles to extend the use of low kV to even larger patient sizes. In these cases, the GE Reference Profiles were used as a starting point for the User Profiles.

Figure 20 shows the distribution of kV Modes (kV Assist, Auto Prescription, and Manual kV) and kV across the three scanners for all Chest, Cardiac, and Abdomen/Pelvis protocols. Using Auto Prescription on the Revolution Apex enabled significantly lower kV scanning. While the two Revolution CT systems were not yet using Auto Prescription protocols, it is expected that using Auto Prescription on the Revolution CT will yield a similar shift from higher to lower kVs through use of Auto Prescription Profiles (as is shown in the results for Clinical Site #2 in the following section).

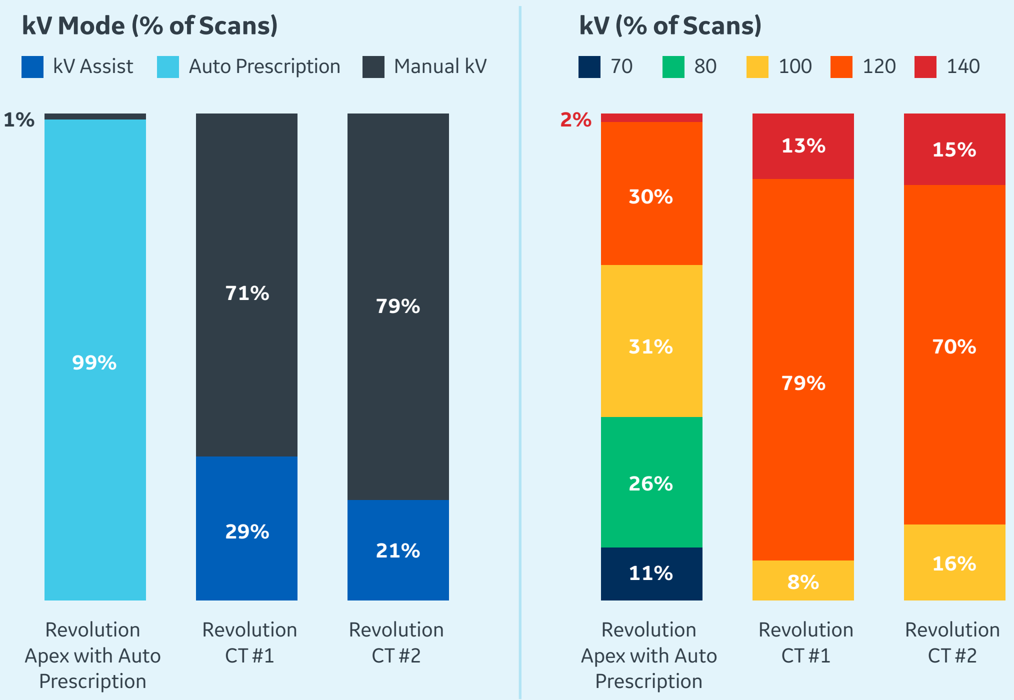
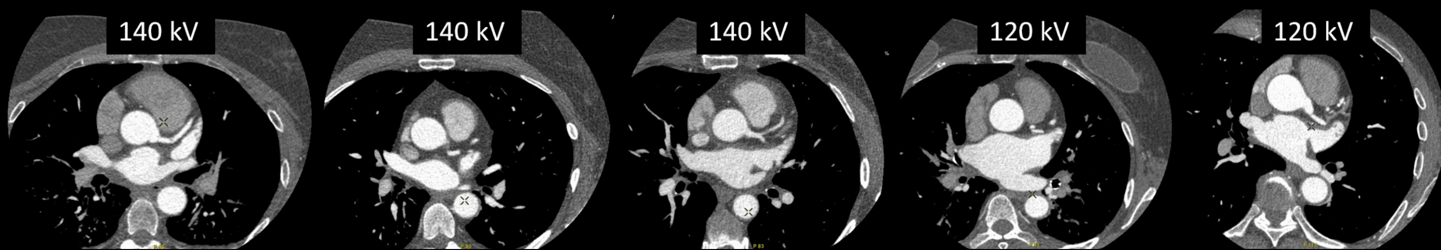


Figure 20. kV Mode and kV utilization for three GE Revolution platforms at one institution for all Chest, Cardiac, and Abdomen/Pelvis protocols. Using Auto Prescription on the Revolution Apex enabled significantly lower kV scanning. While the two Revolution CT systems did not yet have Auto Prescription installed, it is expected that using Auto Prescription on the Revolution CT will yield a similar shift from higher to lower kVs.

Figure 21 shows example images acquired from the same institution. All images were Cardiac CT Angiography (CCTA) of larger-than-average patient sizes. Images from the Revolution CT without Auto Prescription were acquired at 120 or 140 kV, while images from the Revolution Apex with Auto Prescription were acquired at 70, 80, or 100 kV. In all cases, image quality was deemed acceptable. For the lower kV cases on Revolution Apex, a noticeable increase in contrast enhancement was observed.

CCTA images for large patients acquired on Revolution CT without Auto Prescription



CCTA images for large patients acquired on Revolution Apex with Auto Prescription

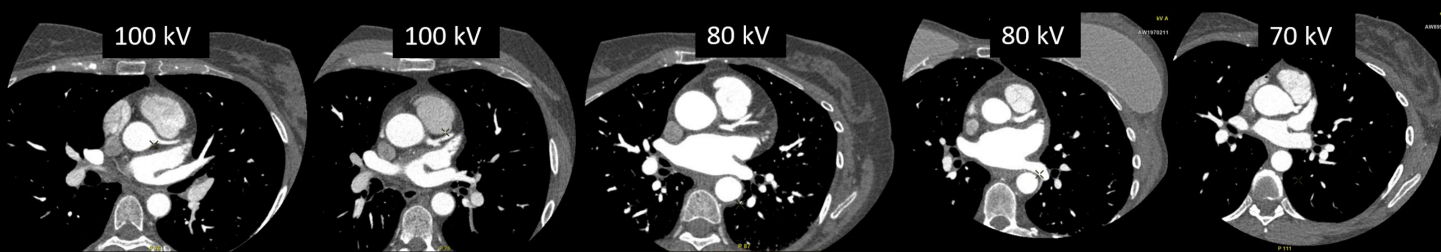
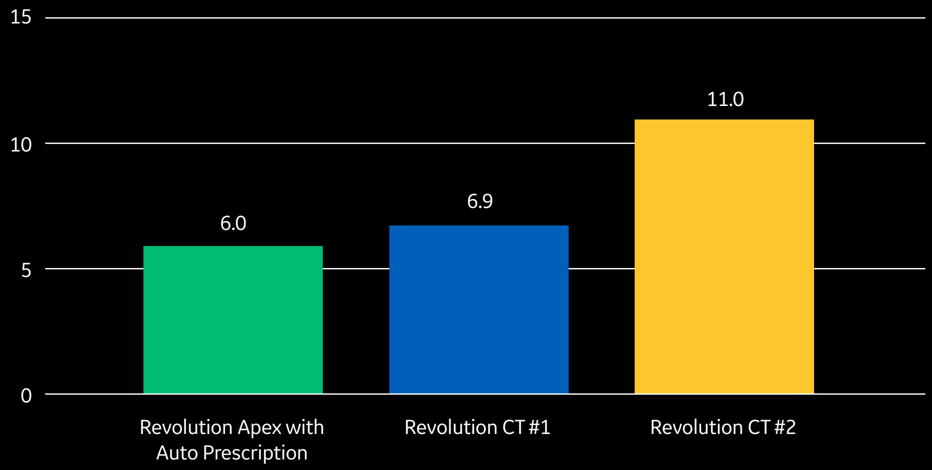


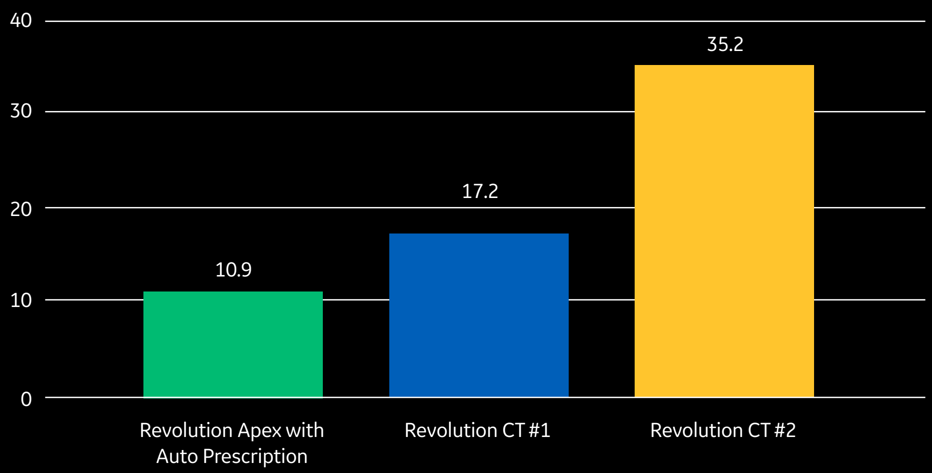
Figure 21. CCTA images for large patients acquired on Revolution CT without Auto Prescription (top row) and on Revolution Apex with Auto Prescription (bottom row). Images acquired with Auto Prescription tended toward lower kV with subjectively similar image quality. WW/WL values for the images in the top row are 800/100. WW/WL values for images in the bottom row are 870/110 (100 kV), 960/115 (80 kV), and 1100/140 (70 kV).

Figure 22 shows the median CTDIvol for all Chest, Cardiac, and Abdomen/Pelvis protocols. The Revolution Apex with Auto Prescription yields lower overall dose for all three exam types.

Median CTDIvol for Routine Chest and Chest CTA



Median CTDIvol for Cardiac



Median CTDIvol for Routine Abdomen/Pelvis and Body CTA

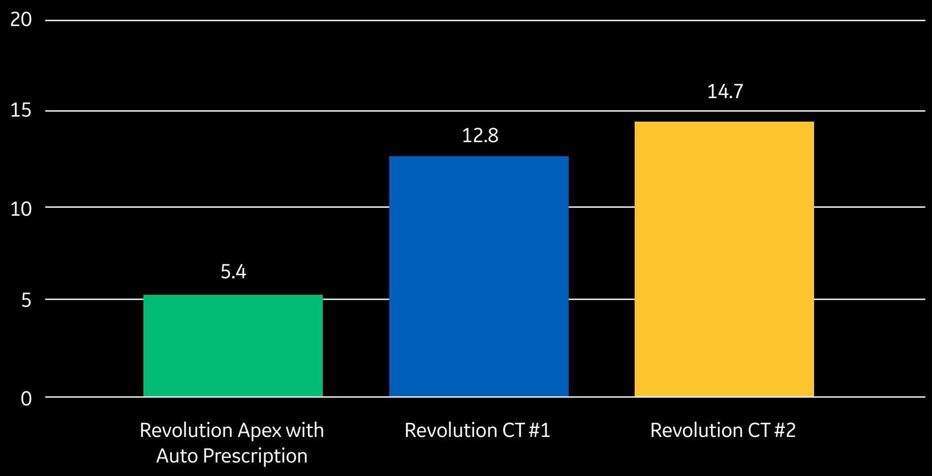


Figure 22. Median CTDIvol for three GE Revolution platforms at one institution for all Chest, Cardiac, and Abdomen/Pelvis protocols. Revolution Apex with Auto Prescription yields lower overall dose for all three exam types.

In addition to facilitating low kV imaging, Auto Prescription allowed this institution to eliminate many of their size-based protocols, instead replacing them with Auto Prescription Profiles, which automatically adjust scan settings based on patient size.

Clinical Site #2: Revolution CT

Several exams were performed on a Revolution CT using Auto Prescription with GE Reference Profiles. The CTDIvol and image quality were compared to each patient's prior image acquired on the Revolution CT without Auto Prescription. In each case, Auto Prescription resulted in lower kV selection, lower CTDIvol, and diagnostically acceptable image quality, as scored by a radiologist.

Case	Exam type	kV (Prior)	CTDIvol (Prior) [mGy]	kV (Auto Prescription)	CTDIvol (Auto Prescription) [mGy]	% Change in CTDIvol using Auto Prescription vs. Prior	Auto Prescription Profile
1	Chest	100	7.39	70	2.39	-68%	GE Thorax
2	Chest	100	6.61	70	2.23	-66%	GE Thorax
3	Chest	120	8.00	80	5.25	-34%	GE Thorax
4	Abdomen/ Pelvis	120	17.78	100	11.23	-36%	GE Abdomen/ Pelvis

CASE 1

Routine Chest | 68% reduction in CTDIvol

Prior
100 kV/7.39 mGy

Auto Prescription
70 kV/2.39 mGy

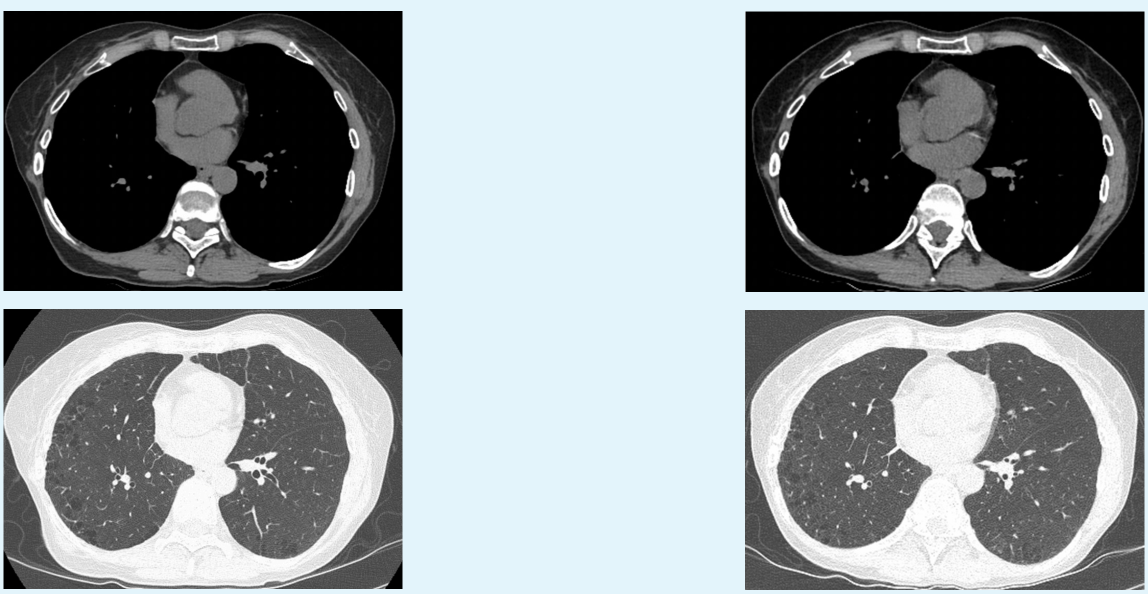


Figure 23. Same patient scanned on Revolution CT at 100 kV/7.39 mGy without Auto Prescription and at 70 kV/2.4 mGy with Auto Prescription (GE Thorax Profile). Both images were reviewed by a radiologist and rated above acceptable image quality. Reconstructions were performed using DLIR-M (top) and ASiR-V 0 (bottom).

CASE 2

Routine Chest | 66% reduction in CTDIvol

Prior 100 kV/6.61 mGy → **Auto Prescription** 70 kV/2.23 mGy

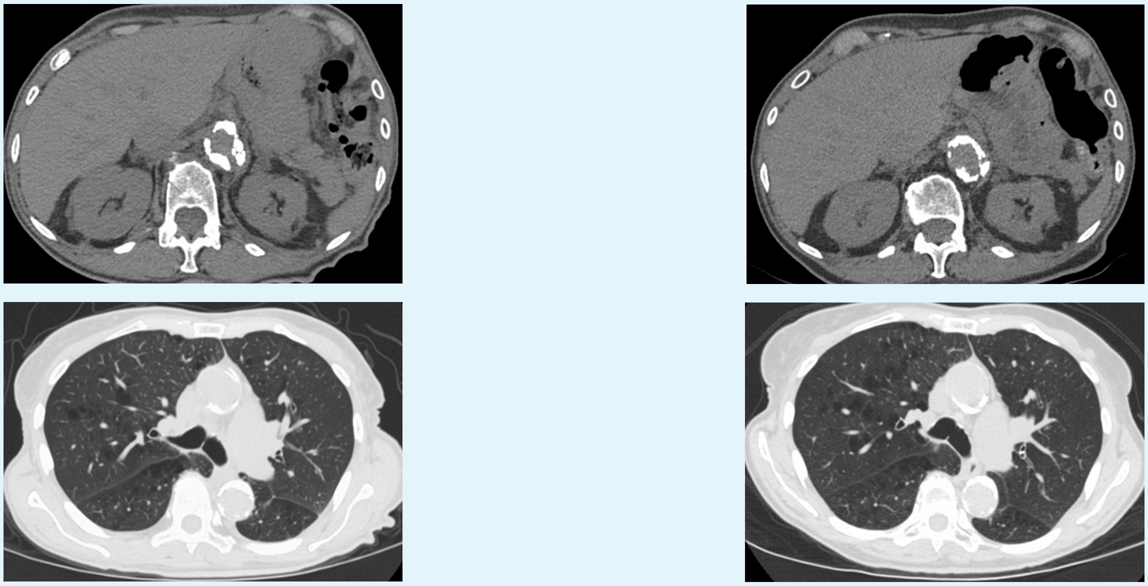


Figure 24. Same patient scanned on Revolution CT at 100 kV/6.61 mGy without Auto Prescription and at 70 kV/2.23 mGy with Auto Prescription (GE Thorax Profile). Both images were reviewed by a radiologist and rated above acceptable image quality. Reconstructions were performed using DLIR-M (top) and ASiR-V 0 (bottom).

CASE 3

Routine Chest | 34% reduction in CTDIvol

Prior 120 kV/8.00 mGy → **Auto Prescription** 80 kV/5.25 mGy

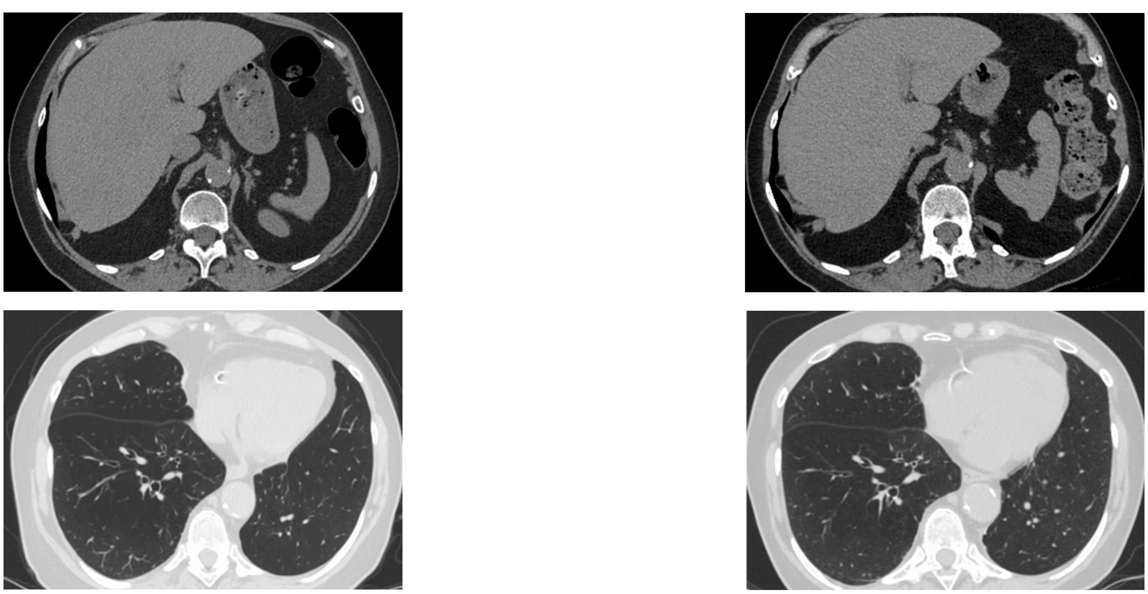


Figure 25. Same patient scanned on Revolution CT at 120 kV/8 mGy without Auto Prescription and at 80 kV/5.25 mGy with Auto Prescription (GE Thorax Profile). Both images were reviewed by a radiologist and rated above acceptable image quality. Reconstructions were performed using DLIR-M (top) and ASiR-V 0 (bottom).

CASE 4

Routine Abdomen/Pelvis | 36% reduction in CTDIvol

Prior
120 kV/17.78 mGy

Auto Prescription
100 kV/11.23 mGy

Figure 26. Same patient scanned on Revolution CT at 100 kV/17.78 mGy without Auto Prescription and at 100 kV/11.23 mGy with Auto Prescription (GE Abdomen/Pelvis Reference Profile). Both images were reviewed by a radiologist and rated above acceptable image quality. Reconstructions were performed using DLIR-L.

Conclusions

Auto Prescription is GE Healthcare's latest offering on the road toward more personalized scanning and simplified, automated workflow. Going beyond its predecessor, kV Assist, Auto Prescription not only selects the optimal kV and Noise Index settings for a given patient size and clinical intent, but also allows for automatic changes in pitch, rotation time, minimum and maximum mA limits, and other scan settings based on patient size.

Auto Prescription benefits Lead Technologists and Medical Physicists by eliminating size-based protocols, providing GE Reference Profiles, and allowing creation of custom User Profiles.

Auto Prescription benefits Scan Technologists by simplifying protocol selection, enhancing workflow, and reducing the need to make scan-time adjustments.

Auto Prescription benefits Radiologists by providing consistent and acceptable image quality.

And Auto Prescription ultimately benefits patients by assuring the right scan settings, dose, and image quality are achieved for every patient, every time.

Glossary

Term	Definition
AP	Anterior-posterior measurement of a patient. Can be taken from a lateral scout, an axial image, or calculated from water equivalent diameter using conversion factors. Auto Prescription calculates AP by converting water equivalent diameter.
AP + Lat	AP + Lat measurement of a patient. Can be taken by summing the AP and Lateral measurements from a scout or axial image, or calculated from water equivalent diameter using conversion factors. Auto Prescription calculates AP + Lat by converting water equivalent diameter.
Auto Prescription	Auto Prescription is a profile-driven feature that selects kV, pitch, rotation time, and other scan settings automatically based on patient size, as well as optimizes the Prescribed Noise Index and WW/WL.
Auto Prescription Profile	A re-usable element defining scan acquisition settings as a function of patient size.
Auto WW/WL	Enabling Auto WW/WL will automatically set the appropriate WW and WL the image based on the selected kV and NI to match how the image would have looked if acquired at the Reference kV and Reference Noise Index.
Clinical Task	A setting in the Auto Prescription Profile that determines the amount of noise increase or decrease as kV is changed.
CNR	Contrast-to-Noise Ratio
Dw	Water Equivalent Diameter (cm), the x-ray attenuation of a patient can be expressed in terms of a water cylinder having the same x-ray absorption. The diameter of such a cylinder of water is referred to as the Water Equivalent Diameter.
GE Reference Profile	GE Reference Profiles come pre-loaded onto the scanner and are designed specifically for a variety of clinical indications.
Lat	Lateral measurement of a patient. Can be taken from an AP scout, an axial image, or calculated from water equivalent diameter using conversion factors. Auto Prescription calculates Lat by converting water equivalent diameter.
Noise Index (NI)	The Noise Index approximates the standard deviation in the central region of the image when a uniform phantom (with the patient's attenuation characteristics) is scanned and reconstructed using the standard reconstruction algorithm. The Noise Index corresponds to the relative level, or index, of noise in the reconstructed image: a higher Noise Index means the images will contain relatively more noise and will be obtained with lower mA, therefore lowering relative patient dose, while a lower Noise Index means the images will contain relatively less noise and will be obtained with higher mA, leading to relatively higher patient dose.
Prescribed Noise Index (Prescribed NI)	The Noise Index that is prescribed for a particular scan.
Projected Noise Index (Projected NI)	The Noise Index that is projected to be achieved for a particular scan. For example, the user may set a Prescribed NI of 10, but the Projected NI may be higher if the level of mA required to meet a Prescribed NI of 10 is not available.
Reference kV	The kV set for the Reference Patient Size
Reference Noise Index (Reference NI)	The Noise Index set for the Reference kV and Reference Patient Size. At scan time, Auto Prescription will use the Reference Noise Index, Reference kV, and Reference Patient Size to determine the Prescribed NI that should be used for the selected kV, Clinical Task, and Size-Adjusted NI from the Auto Prescription Profile, as well as the patient size.
Reference Patient Size	Nominal patient size of 58 cm AP + Lat (approximately 75 kg, 165 lbs, or 28.9 cm water equivalent diameter)
SANI	Size-Adjusted Noise Index
User Profile	An Auto Prescription Profile created by the user.
WL	Window Level
WW	Window Width

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