Project no. FP6/002388

CT Safety & Efficacy

Safety and efficacy of computed tomography (SECT): a broad perspective

SPECIFIC TARGETED RESEARCH PROJECT

EURATOM Call 2003

WP1.D5
Recommendations for MSCT referral

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I Justification

The medical process

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<th>treatment</th>
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</tr>
</tbody>
</table>

Diagnostic imaging

- multi slice computed tomography MSCT
- new generation CT systems: accurate and fast
- at least 16 slices simultaneously

Justification: safety and efficacy

- safety of MSCT
  - radiation effects: cancer and leukaemia
  - contrast agents: severe allergic reaction
- efficacy of MSCT
  - diagnostic accuracy: sensitivity and specificity
  - correct diagnosis: appropriate treatment
  - more diagnoses found in anatomic region
II Medical decision-making

Medical decision making: modelling to determine the benefits of MSCT against the adverse effects
⇒ recommendations and guidelines

Clinical decision: IF diagnostic tests = pos THEN treatment
Model-based decision: IF probability of disease = high THEN treatment

Models for medical decision-making

1 Graphical models for medical decision analysis
2 General structure of the model
3 Causal modelling
4 Model patterns
5 Evidence-based conditional probabilities
6 Outcomes: health-related utilities

General structure of the model

1 Entry point
   – main diagnose or symptom with differential diagnoses, patient groups and prior probabilities.
2 Diagnostic part
   – diagnostic policies, diagnostic tests, and diagnostic imaging, and conditional probabilities.
3 Treatment part
   – treatment policies and treatments only to determine the outcomes. Includes negative treatment.
4 Utilities part
   – outcomes of a decision path of diagnostic and treatment choices as health-related utilities.

Model-based guideline development

– Medical decision model
– Guideline extraction
– Diagnostic algorithm
– Recommendations
### III Study overview

<table>
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<th>ICD10</th>
<th>head and neck</th>
<th>thorax</th>
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<td>nonacute headache (UCM); mild head trauma (LUMC)</td>
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<td>9 Diseases of the circulatory system</td>
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<td>11 Diseases of the digestive system</td>
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<td>acute abdominal pain: appendicitis (LUMC); abdominal sepsis (UOXF)</td>
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<td>13 Diseases of the musculoskeletal system and connective tissue</td>
<td>cervical-spine trauma (UoC)</td>
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<td>low back pain (UCM)</td>
<td>sterno-clavicular joint imaging (AUH)</td>
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<tr>
<td>14 Diseases of the genitourinary system</td>
<td></td>
<td></td>
<td>haematuria: urothelial cancer (UoC); acute flank pain: urolithiasis (UHBS)</td>
<td></td>
</tr>
</tbody>
</table>
Research question

- Identification of patient groups who may benefit from MSCT, including the determination of the proper indications and preliminary diagnostic tests for selective referral.
- Determination of the diagnostic accuracy of MSCT in different settings.
- Comparison of MSCT with other alternative diagnostic imaging modalities.
- Determination of the radiation dose of MSCT on patient-level.
- Dose reduction by taking less sequences/ phases or lower exposure settings while maintaining the required diagnostic accuracy.

Reduction of diagnostic radiation dose

- Selective referral based on the determination of the proper indications, preliminary diagnostic tests, and patient groups.
- Dose reduction by taking less sequences/ phases or lower exposure settings while maintaining the required diagnostic accuracy.
- Finding alternatives to CT, especially for groups at risk by comparison of MSCT with non-radiative diagnostic imaging modalities.

Benefits and risks

- Patient groups who may benefit
  - good survival if treated properly
  - age of interest: 13 - 80
  - high risk if diagnosis is missed immediate
  - temporary disfunction intermediate
  - permanent disfunction long term
- Risks of diagnostic imaging and intervention
  - severe allergic reaction immediate
  - mortality and morbidity immediate
- Risks of diagnostic radiation
  - solid cancer long term
  - leukaemia intermediate
1 Non-acute headache

Non-acute headache: neurological evaluation and diagnostic imaging

Characteristics of patients and usefulness of neuroimaging in non acute headache – meta-analysis and prospective study – UCM
Verónica Alonso Ferreira, Cesar Cordeiro Alves, Isabel Salmerón Béliz, Eduardo Fraile Moreno, Carlos Gómez-Escalonilla, Alfonso Calzado Cantera

2d. Supporting evidence for the optimal diagnostic strategy through prospective studies
Neuroimaging tests are only indicated when “red flags” are present. The first option should be MRI because it does not involve ionizing radiation.

2e. Third set of general recommendations on diagnostic strategies involving CT
MSCT is a good alternative for adult patients, since its sensitivity and specificity values are comparable to those from MRI. In addition, both the dose levels and the risks involved are relatively low.

2004 Quality criteria for MSCT
Brain - general

Model
Non acute headache
2 Mild head trauma

Mild head trauma: identification of patient groups

Mild head trauma: identification of specific patient groups—meta-analysis and retrospective study—LUMC
Ying-Lie O, Eduard Bollen (neurology), Ellen Beekman (medical coding), Liz Terveer (data assistant), Jan Molenaar (data query)

2d. *Supporting evidence for the optimal diagnostic strategy through prospective studies*
CT is the gold standard for head trauma. This retrospective study identified different patient groups for whom MSCT would have been beneficial. This also includes patients with alcohol intoxication or drugs abuse. Unfortunately, these patients were often not accompanied by a sober person who is competent to perform home observation.

2e. *Third set of general recommendations on diagnostic strategies involving CT*
It is recommended to follow the guidelines for CT referral evaluated in the latest large validation studies, and make adaptations for the management of specific local patient groups such as bicycle accidents and falls from stairs in the Netherlands.

2004 Quality criteria for MSCT
*Brain - general*
3 Cervical spine trauma

Multi-slice CT versus conventional radiography in the cervical spine trauma clearance and the role of scout view in patients presenting with low or intermediate severity trauma

Multi-slice CT versus conventional radiography in the cervical spine trauma clearance and the role of scout view in patients presenting with low or intermediate severity trauma – meta-analysis and prospective study – UoC
Konstantinos Chlapoutakis, Nicholas Theocharopoulos, Yiannis Damilakis

2d. Supporting evidence for the optimal diagnostic strategy through prospective studies
A meta-analysis and systematic review of the published literature confirms superiority of performance of MSCT vs. plain radiography for the clearance of patients suspected with cervical spine injury. However, CT examinations are associated with relative high dose to the patient compared to conventional radiography and therefore bare the potential of late radiation effects such as leukaemia and solid cancers. Hence, CT utilization is justified when the benefit (diagnostic accuracy) over risk (radiation effects) ratio is higher compared to other available imaging modalities.

2e. Third set of general recommendations on diagnostic strategies involving CT
Irrespectively of risk group stratification (determined by the mechanism of trauma and the patient age) and patient radiosensitivity (depending on age at irradiation), the use of CT for the evaluation of the Cervical Spine trauma is always associated with increased probability of achieving an end health state of high value compared to conventional radiography. In other words, higher diagnostic accuracy obtained by the MSCT examination counterbalances the increase in dose compared to plain film evaluation, and renders CT utilization dose effective and justified, since a missed Cervical Spine fracture may lead to significant deterioration of the patient’s quality of life (paralysis).

2004 Quality criteria for MSCT
Cervical vertebrae – trauma
4 Acute chest pain: coronary artery disease

Model- and evidence-based indications for computed tomography coronary angiography in patients suspected for coronary artery disease

Model- and evidence-based indications for computed tomography coronary angiography (CTCA) in patients suspected for coronary artery disease – a meta-analysis – LUMC
Alex Meijer, Lucia Kroft (radiology), Ying-Lie O, Koos Geleijns

2d. Supporting evidence for the optimal diagnostic strategy through prospective studies
Meta-analysis showed very good sensitivity and good specificity of 40- and 64-slice CT coronary angiography (CTCA) for the detection of significant coronary artery stenoses. Irregular and fast heart rates remain a problem as these often render an examination non-diagnostic. A model-based efficacy study showed that age and gender have little effect on the range of clinical probability where CTCA is optimal. Age and gender do have a large impact on clinical probability itself and whether this falls within the range of probabilities where CTCA is indicated.

2e. Third set of general recommendations on diagnostic strategies involving CT
The current practice of the use of 40- and 64-slice CT coronary angiography (CTCA) in suspected coronary artery disease (CAD) seems to be justified in patients with a low to intermediate probability for CAD (2-50%) after clinical evaluation and monitoring. For very low probabilities (below 6%), it seems most effective to assume non-diagnostic scans negative.
5 Acute chest pain: pulmonary embolism

Detectability of subsegmental pulmonary vessels in CT pulmonary angiography

Detectability of subsegmental pulmonary vessels in CT pulmonary angiography (CTPA) – meta-analysis and prospective study – UHBS
Tilo Niemann, Georg Bongartz

2d. Supporting evidence for the optimal diagnostic strategy through prospective studies
A review of the current literature demonstrates a tendency to abstain from any treatment in patients with isolated subsegmental pulmonary embolism. If the depiction of isolated subsegmental pulmonary embolism hence proves to be without significant clinical impact the resolution can be reduced during image reading by the radiologist (i.e. reading thicker slices and thick multiplanar reformats (MPR’s)). This preserves visualization of the segmental pulmonary arteries and the majority of subsegmental ones.

2e. Third set of general recommendations on diagnostic strategies involving CT
CT pulmonary angiography (CTPA) remains the gold standard in imaging suspected pulmonary embolism. Ultra-thin collimation image reading seems to be without any impact and is not indicated in the majority of the patient population. Reduction of the resolution during image reading by the radiologist has the inherent potential for dose reduction: at the stage of image acquisition by modifying the tube current and tube voltage.

2004 Quality criteria for MSCT
Vascular - chest - CTPA

Model
Acute chest pain
6  Acute abdominal pain: appendicitis

Acute abdominal pain: scoring, diagnostic imaging, and intervention in appendicitis

Characteristics of scoring variables, diagnostic imaging, and intervention in suspected appendicitis – meta-analysis, retrospective and prospective observation studies – LUMC
Ying-Lie O, Eric Benjamins, Job Kievit, Jaap Sont
Liz Terveer (data manager), Martijn Möllers (surgery), Wendeline van der Made (surgery), Koos Mistrate Haarhuis (data query)

2d.  Supporting evidence for the optimal diagnostic strategy through prospective studies
In Europe, ultrasound is the preferred imaging modality for suspected appendicitis in particular, and acute abdomen in general. In the USA, CT is the preferred imaging modality because of its high accuracy. This study found that almost all patients with acute lower abdominal pain had ultrasound. False positive cases where CT would have been beneficial have been identified.

2e.  Third set of general recommendations on diagnostic strategies involving CT
Ultrasound is the primary modality of imaging in acute abdominal pain. CT should be performed in clinically equivocal cases:
− a reasonable suspicion of other diseases
− the inflammatory markers are not elevated
− results of US are uncertain or the appendix is not visible
Specific indications for CT based on signs and laboratory results in appendicitis scoring, and indications for other acute abdomen diseases should be determined more precisely.

Model
Acute abdominal pain
7 Abdominal sepsis

Abdominal sepsis: diagnostic accuracy of detecting abdominal sepsis

What is the diagnostic accuracy of detecting causes of abdominal sepsis with multi-slice computed tomography? – meta-analysis and prospective study – UOXF
Stuart Meeson, Christopher Alvey, Stephen Golding

2d. Supporting evidence for the optimal diagnostic strategy through prospective studies
Diagnostic accuracy data for MSCT scans using 16 slices confirm CT remains a suitable modality for imaging causes of abdominal sepsis. The clinical role of CT has not changed with the development of new technology, using MSCT with 16 or more slices. There is no distinct group of clinical indications that are suggestive of abdominal sepsis. Spectrum of exposures produced currently in practice are presented, which represent the baseline for potential dose constraint in follow-up studies.

2e. Third set of general recommendations on diagnostic strategies involving CT
Patients presenting for initial diagnosis should receive a full scan of the peritoneal cavity. Repeated use of MSCT during abdominal sepsis drainage can lead to rapid increases in cumulative dose, particularly for patients with large cross-sectional areas (measured for the abdomen at the level of vertebra L3). Patients who have been treated successfully may not need a follow-up scan. A low dose and region specific scan can be used for removal of catheter and confirmation that the collection has resolved fully. If a patient is not responding or getting worse after catheterisation, a repeat full diagnostic scan is required to check catheter location and search for further sites of infection.

2004 Quality criteria for MSCT
Abdomen and pelvis – general
8 Testis cancer: retroperitoneal spread

Diagnostic value of MSCT and MRI in the diagnosis of retroperitoneal spread of testicular cancer

Diagnostic value of MSCT and MRI in the diagnosis of retroperitoneal spread of testicular cancer – meta-analysis and comparative prospective study – AUH
Jolanta Hansen, Karen Jong-Nyo Berenth Madsen, Anne-Grethe Jurik

2d. Supporting evidence for the optimal diagnostic strategy through prospective studies
Meta-analysis and search for guidelines did not result in information regarding diagnostic accuracy of MSCT and MRI for detecting retroperitoneal spread of testicular cancer. CT is therefore still the recommended standard for detecting spread of testicular cancers. Preliminary results of the prospective study are promising with regard to visualisation of retroperitoneal structures at MRI, but valid data await the final results. The study may reveal valid evidence for substituting MSCT with MRI for detecting retroperitoneal spread of seminomatous testicular cancer.

2e. Third set of general recommendations on diagnostic strategies involving CT
Testicular seminoma primarily spread to the retroperitoneal glands and if chest x-ray is normal there is no need for chest CT. In these patients MRI could be advantageous giving the possibility of avoiding a series of follow-up CT examinations of the retroperitoneum. In non-seminomatous tumour there can be spread to other locations which demands CT examination. The use of MRI of the retroperitoneum in these patients will therefore often be in combinations with CT of other regions which maybe inconvenient to the patient.

2004 Quality criteria for MSCT
Abdomen and pelvis – general
9 Haematuria: urothelial cancer

Multi Detector CT Urography for the detection of Upper Urinary Tract Transitional Cell Carcinoma

Multi Detector CT Urography (CTU) for the detection of Upper Urinary Tract Transitional Cell Carcinoma (UUT TCC) – meta-analysis and prospective study – UoC
Konstantinos Chlapoutakis, Nicholas Theocharopoulos, Yiannis Damilakis

2d. Supporting evidence for the optimal diagnostic strategy through prospective studies
Irrespectively of patient sex and age older than 40 years at irradiation, the use of multi-slice computed tomographic urography (CTU) for the evaluation of haematuria is always associated with lower total risk of detriment, resulting from missed or false diagnosis and exposure to radiation, compared to other imaging modalities.

2e. Third set of general recommendations on diagnostic strategies involving CT
Despite the increased radiation burden, the low false negative and false positive rates achieved with MSCT, make multi-slice computed tomographic urography (CTU) the method of choice for adult patients older than 40 years screened positive for haematuria, when medical renal disease and bladder cancer are excluded. Although upper urinary tract (UUT) transitional cell carcinoma (TCC) is an aggressive disease, the post surgery (Radical nephroureterectomy, RNU) survival rates are high. Therefore accurate diagnosis is essential even at the cost of increased radiation burden.
In younger patients, where aggressive imaging investigation is justified, further dose reduction can be possibly achieved by single-phase examinations, split-bolus contrast administration and combinations of scanning phases, as has been very recently suggested in the literature.

2004 Quality criteria for MSCT
Abdomen - kidneys

Model
Painless haematuria
10 Acute flank pain: urolithiasis

Urolithiasis low dose CT

Detection of Urolithiasis using low dose CT – meta-analysis and noise simulation study – UHBS
Tilo Niemann, Georg Bongartz

2d. Supporting evidence for the optimal diagnostic strategy through prospective studies
Diagnostic accuracy of CT for the detection of urolithiasis is reported higher than intravenous urography (IVU). Modern CT scanners provide automatic exposure control tools (AEC) for weight-independent dose reduction. Using a CT protocol with automatic tube current modulation for detection of urolithiasis allows a weight-independent dose reduction down to 4.5 mSv (IVU 2.6 mSv) in standard dose protocols. Further decreasing the radiation dose down to 50% of the standard dose results in still excellent sensitivities/specificities of 0.98 / 0.99. A further decrease down to 25% of standard dose protocols results in still acceptable sensitivity/specificity of 0.92 / 0.98 and can be recommended for follow-up studies.

2e. Third set of general recommendations on diagnostic strategies involving CT
Detection of high-density structures such as concrements allows significant dose reduction without significant loss of sensitivity/specificity. AEC enables dose reduction even in obese patients. Therefore, a low-dose CT protocol in the work-up of suspected urolithiasis can be used as first-line imaging modality. Fixed tube current protocols should be avoided whenever possible. Highest image quality in terms of low image noise is not always mandatory for establishing the diagnosis. Radiologists should be encouraged to evaluate the yield of lower radiation studies with increased noise level.

2004 Quality criteria for MSCT
Abdomen – urolithiasis

Model
Acute flank pain
11 Sternoclavicular joint imaging

Diagnostic value of MSCT and MRI for imaging sternoclavicular joint disorders

Diagnostic value of MSCT and MRI for imaging sternoclavicular joint disorders – meta-analysis and comparative prospective study – AUH
Jolanta Hansen, Karen Jong-Nyo Berenth Madsen, Anne-Grethe Jurik

2d. Supporting evidence for the optimal diagnostic strategy through prospective studies
Meta-analysis and search for guidelines did not result in valid information regarding recommendation for imaging the sterno-costo-clavicular (SCC) region. Based on the preliminary results of our prospective study, which will be finalised in 2008, it seems that MRI is not able to visualise osseous structures as clearly as MSCT, but it is superior with regard to soft tissue inflammation and lesion of the intra-articular disc. CT will therefore probably still be the modality of choice in the imaging of the sternoclavicular joint region unless the suspected abnormalities predominantly involve soft tissue structures. The blinded analysis will when finalised contribute with some valid data regarding this.

2e. Third set of general recommendations on diagnostic strategies involving CT
MSCT is the modality of choice for imaging the SCC region until there for some disorders is evidence proving a diagnostic value of MRI comparable to that of CT. It may sometimes be necessary to supplement MSCT with MRI if the soft tissue ought to be visualised with high contrast resolution.
12 Low back pain

Low back pain: diagnostic imaging and follow-up

MSCT findings in patients with low back pain and follow-up – meta-analysis and prospective study – UCM
Verónica Alonso Ferreira, Cesar Cordeiro Alves, Isabel Salmerón Bélix, Eduardo Fraile Moreno, Alfonso Calzado Cantera

2d. Supporting evidence for the optimal diagnostic strategy through prospective studies
Whenever an imaging test is warranted the first option should be MRI, due to its high diagnostic accuracy and because it does not involve ionizing radiation.

2e. Third set of general recommendations on diagnostic strategies involving CT
When MRI is not available or contraindicated, MSCT is a good alternative since it can reach a similar diagnostic accuracy. In this case the examination must be fully justified by the presence of “red flags”, and the involved dose values should be optimized.

2004 Quality criteria for MSCT
Lumbar and thoracic spine - trauma

Model
Low Back Pain
## IV 2004 Quality criteria for MSCT

### Brain - general

**Preparatory steps**

<table>
<thead>
<tr>
<th>Indication</th>
<th>Traumatic lesions of the brain. Suspected or known focal or diffuse structural disease when MRI is contraindicated or not available.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Advisable preliminary or alternative investigations</td>
<td>Clinical neurological examination. MRI is an alternative examination without exposure to ionising radiation.</td>
</tr>
<tr>
<td>Patient preparation</td>
<td>Appropriate consent. Exclude radiodense items, whenever possible.</td>
</tr>
<tr>
<td>Scan projection radiograph</td>
<td>Lateral: skull base to vertex.</td>
</tr>
</tbody>
</table>

**Acquisition objectives**

| Target volume | Entire brain. Where possible, gantry angulation and appropriate head positioning should be applied to minimise exposure to the eye lenses. |
| Image weighting | Contrast resolution |
| Exposure | Exposure parameters should be adjusted to patient size, especially in paediatric patients. |
| Beam collimation | 4 slice medium (1 - 2.5 mm); 16 slice small - medium (< 1 mm; 1 - 2.5 mm) |
| Pitch | Low (< 0.9) |
| CTDI volume | < 60 mGy; high (head phantom) |
| Tube voltage | Medium (110 – 130 kV) |

**Image reconstruction**

Viewing slice thickness defines exposure parameters. MPR is not obligatory, but may facilitate evaluation of lesions; this requires thin collimation and thin primary sections.

| Primary reconstruction section thickness | Adapted to beam collimation (in case of MPR). |
| Overlap of primary reconstruction | 0-50% |
| Reconstruction algorithm | Soft tissue smooth |
| Field of view | Corresponding to head |
| Viewing slice thickness | Medium. |
| Overlap of viewing slices | None required. |
Brain - general

Image quality criteria, visualization
1. Entire cerebrum.
2. Entire cerebellum and brain stem

Image quality criteria, critical reproduction
1. Reproduction of the border between white and grey matter.
2. Reproduction of the basal ganglia.
3. Sharp reproduction of the ventricular system.
4. Sharp reproduction of major vessels after intravenous contrast (enhanced slices).

Contrast media
Enhancement may be valuable for delineating lesions.
Dose and concentration 50-100 ml, 300 mg/l/ml.
Flow rate Not critical.
Delay and timing 60-120s depending on suspected pathology.

Modification to technique
Additional slices may be reconstructed with an appropriate algorithm to evaluate osseous structures.
The target volume may be extended to include the cervical spine and/or face in trauma patients with suspected pathology.
On some systems only non-helical scanning (incremental acquisition) provides adequate image quality.
Abdomen and pelvis - general

Preparatory steps
Indication  Diagnosis of intra-abdominal pathology, abdominal staging and monitoring of malignant disease, trauma
Advisable preliminary or alternative investigations  Ultrasonography or MRI may be alternative examinations
Patient preparation  Appropriate patient consent. Exclude radiodense items, whenever possible. Barium residue from previous gastrointestinal studies may preclude CT. Oral contrast media or water may be used for gastrointestinal demarcation. Rectal contrast media may be applied selectively
Scan projection radiograph  Frontal: mid chest to upper thigh

Acquisition objectives
Target volume  From diaphragm to inferior border of the pubic symphysis.
Image weighting  Contrast resolution
Exposure  Exposure parameters should be adjusted to patient size.
Beam collimation  4 slice medium - large (1 - 2.5 mm; > 2.5 mm); 16 slice small - medium (< 1 mm; 1 - 2.5 mm)
Pitch  Medium - high (0.9 - 1.3; >1.3)
CTDI volume  < 15 mGy; medium (trunk phantom)
Tube voltage  Medium (110 – 130 kV)

Image reconstruction  Viewing slice thickness defines exposure parameters. MPR is not obligatory but may facilitate evaluation of lesions
Primary reconstruction section thickness  Adapted to beam collimation
Overlap of primary reconstruction  0-50%
Reconstruction algorithm  Soft tissue standard
Field of view  Corresponding to the abdominal region
Viewing slice thickness  Medium - large
Overlap of viewing slices  0 – 30%
Abdomen and pelvis - general

**Image quality criteria, visualization**
1. Entire abdominal contents
2. Entire diaphragms
3. Entire bladder
4. Abdominal wall muscles

**Image quality criteria, critical reproduction**
1. Sharp reproduction of the gall bladder wall and major intrahepatic ducts (enhanced slices).
2. Sharp reproduction of the intrapancreatic part of the common bile duct (enhanced slices).
3. Sharp reproduction of major branches of the abdominal aorta (enhanced slices).
4. Sharp reproduction of renal pelvis and perirenal fascia.
5. Sharp reproduction of urinary bladder wall (enhanced slices).

**Contrast media**
- Enhancement may increase sensitivity and specificity.
- **Dose and concentration**: 80-120ml, 300mg l/ml
- **Flow rate**: 2-3ml/s, preferably by power injector
- **Delay and timing**: 60 - 80s ("portal phase")

**Modification to technique**
- In suspected abdominal hemorrhage, unenhanced imaging is recommended.
- Target volume of interest may be limited in selected cases according to clinical indication.
- In cases of trauma the entire osseous pelvis may be included.
- In cases of osseous pathology (esp. in trauma cases), additional bone algorithm reconstructions may be applied.
Abdomen - kidneys

Preparatory steps
Indication Diagnosis, staging and monitoring of focal renal and perirenal lesions. Rarely indicated in paediatric patients

Advisable preliminary or alternative investigations Ultrasonography. MRI is an alternative examination, especially in paediatric and young adult patients.

Patient preparation Appropriate patient consent. Exclude radiodense items, wherever possible

Scan projection radiograph Frontal: lower chest to hip joints

Acquisition objectives
Target volume Entire kidneys including adrenals.

Image weighting Contrast resolution

Exposure Exposure parameters should be adjusted to patient size.

Beam collimation 4 slice medium (1 - 2.5 mm); 16 slice small (< 1 mm)

Pitch Medium (0.9 - 1.3)

CTDI volume < 15 mGy; medium (trunk phantom)

Tube voltage Medium (110 – 130 kV)

Image reconstruction Viewing slice thickness defines exposure parameters. MPR is not obligatory but may facilitate evaluation of lesions

Primary reconstruction section thickness Adapted to beam collimation

Overlap of primary reconstruction 0-50%

Reconstruction algorithm Soft tissue standard

Field of view Both kidneys and perirenal spaces

Viewing slice thickness Medium

Overlap of viewing slices 0 – 30%.
Abdomen - kidneys

Image quality criteria, visualization
1. Both perirenal spaces
2. Visualisation of both kidneys and adrenals

Image quality criteria, critical reproduction
1. Sharp reproduction of the renal pelvis and the proximal ureters
2. Sharp reproduction of the adrenal glands
3. Sharp reproduction of the perirenal fascia
4. Sharp reproduction of the renal vessels up to the hilum (enhanced slices)
5. Sharp reproduction of the renal cortex (arterial phase enhanced slices)
6. Sharp reproduction of the internal surface of the renal pelvis (late excretory phase enhanced slices)

Contrast media
Unenhanced and enhanced examination is recommended for characterization of disease. Depending on indication arterial, nephrographic or excretory phases may be recommended.

Dose and concentration 40-80ml, 300mg I/ml.
Flow rate 2-5ml/s, preferably by power injector
Delay and timing 15 – 25s (arterial phase); 80 – 120s (for nephrographic phase); > 240 s (excretory phase).

Modification to technique
In follow-up examinations of known lesions, only enhanced CT sections may be applied.
In appropriate indications, the entire urether and bladder should be included in the target volume at appropriate state of enhancement of the urine.
For staging and monitoring of malignant disease, the target volume of the late phase may be extended according to the “abdomen-pelvis survey” protocol.
Abdomen – urolithiasis

Preparatory steps
Indication Detection, localisation, exclusion and monitoring of urolithiasis with calcified or non-calcified urinary stones

Advisable preliminary or alternative investigations Ultrasonography and / or plain film of the abdomen in cases of known calcified stones

Patient preparation Appropriate patient consent. Exclude radiodense items, wherever possible. Water as negative oral contrast media may be helpful in patients with reduced abdominal fat

Scan projection radiograph Frontal: from xyphoid to upper thigh

Acquisition objectives
Target volume From upper pole of the kidneys to floor of urinary bladder.

Image weighting Contrast resolution

Exposure Exposure parameters should be adjusted to patient size, especially in paediatric patients.

Beam collimation 4 slice medium (1 - 2.5 mm); 16 slice small - medium (< 1 mm; 1 - 2.5 mm)

Pitch Medium (0.9 - 1.3)

CTDI volume < 15 mGy; medium (trunk phantom)

Tube voltage Medium (110 – 130 kV)

Image reconstruction Viewing slice thickness defines exposure parameters. MPR is not obligatory but may help to discriminate between calculus and phlebolith

Primary reconstruction section thickness Adapted to beam collimation

Overlap of primary reconstruction 30-50%

Reconstruction algorithm Soft tissue standard

Field of view Both kidneys

Viewing slice thickness Medium

Overlap of viewing slices 0 - 30%
Abdomen – urolithiasis

**Image quality criteria, visualization**
1. Entire renal parenchyma of both kidneys
2. Both perirenal spaces
3. Entire length of both ureters
4. Entire urinary bladder

**Image quality criteria, critical reproduction**
1. Sharp reproduction of the renal pelvis
2. Reproduction of both ureters
3. Reproduction of the urinary bladder wall

**Contrast media**
None

**Modification to technique**
Following detection of focal pathologies other than urolithiasis, enhanced CT protocols of the suspected area may be applied (see protocols “abdomen-pelvis survey” or “kidneys”).
Vascular - chest - CTPA

Preparatory steps

Indication
Diagnosis of pulmonary embolism; evaluation of suspected or known major vessel aneurysm, dissection or congenital anomaly

Advisable preliminary or alternative investigations
Chest radiography including lateral projection. MRI or transoesophageal ultrasonography may be alternative examinations for major vessels.

Patient preparation
Appropriate consent. Exclude radiodense items whenever possible

Scan projection radiograph
Frontal, lower neck to upper abdomen

Acquisition objectives

Target volume
All chest from apex to costophrenic recess.

Image weighting
Contrast resolution

Exposure
Exposure parameters should be adjusted to patient size, especially in paediatric patients.

Beam collimation
4 slice medium (1 - 2.5 mm); 16 slice small (< 1 mm)

Pitch
Medium - high (0.9 – 1.3; >1.3)

CTDI volume
< 10 mGy; low (trunk phantom)

Tube voltage
Low - medium (< 110 kV; 110 – 130 kV)

Image reconstruction

Viewing slice thickness defines exposure parameters. MPR, 3D or MIP may facilitate evaluation and are recommended for visualization of major vessels.

Primary reconstruction

section thickness
Medium

Overlap of primary reconstruction
0-30%

Reconstruction algorithm
Soft tissue standard

Field of view
Adapted to include whole cross-section of chest

Viewing slice thickness
Medium

Overlap of viewing slices
0-30%
**Vascular - chest - CTPA**

| Image quality criteria, visualization | 1. Entire thoracic aorta and origin of the supra-aortic vessels  
2. Entire heart |
|--------------------------------------|---------------------------------------------------------------|
| Image quality criteria, critical reproduction | 1. Reproduction of thoracic aorta  
2. Reproduction of small vessels within 1cm from the pleural surface  
3. Sharp reproduction of large and medium sized vessels  
4. Sharp reproduction of pleura and mediastinal margin.  
5. Sharp reproduction of endobronchial and endotracheal wall |
| Contrast media | Mandatory. Appropriately timed bolus enhancement is essential |
| Dose and concentration | 80 – 100ml, 370mgI/ml |
| Flow rate | 4-5ml/s, preferably by power injector. |
| Delay and timing | 15 – 25s |
| Modification to technique | When examining disease of major vessels FOV may be limited to include these and the hilar.  
Unenhanced acquisition of the aorta is warranted to rule out intramural haematoma in aortic dissection  
Automatic timing is valuable to avoid untimely acquisition due to variations in cardiac output.  
In cases of aortic dissection target volume may be extended to include abdominal and pelvic arteries |
Cervical vertebrae - trauma

Preparatory steps
Indication: Main indication are traumatic disorders. Similar technique can be used for bone tumours, degenerative, infectious, arthritic and osteonecrotic alterations.

Advisable preliminary or alternative investigations: Conventional radiography; MRI or US are alternative examinations, especially in non-traumatic disorders.

Patient preparation: Appropriate consent. Exclude radiodense items, whenever possible.

Scan projection radiograph: Lateral: forehead to manubrium sterni.

Acquisition objectives
Target volume: Entire cervical spine.
Image weighting: Spatial resolution
Exposure: Exposure parameters should be adjusted to patient size, especially in paediatric patients.
Beam collimation: 4 slice medium (1 - 2.5 mm); 16 slice small (< 1 mm)
Pitch: Low - medium (< 0.9; 0.9 - 1.3)
CTDI volume: < 40 mGy; medium (head phantom)
Tube voltage: Medium (110 – 130 kV)

Image reconstruction
Primary reconstruction section thickness: Adapted to beam collimation.
Overlap of primary reconstruction: 0-50%.
Reconstruction algorithm: High resolution
Field of view: Corresponding to all cross section of the spine including adjacent muscles
Viewing slice thickness: Medium – small.
Overlap of viewing slices: 0 – 25%.
Cervical vertebrae - trauma

Image quality criteria, visualization

1. The entire cervical spine.

Image quality criteria, critical reproduction

1. Sharp reproduction of cortical bone.
2. Sharp reproduction of trabecular bone.
4. Sharp reproduction of the intervertebral radicular canals.
5. Sharp reproduction of the intervertebral disk profiles.

Contrast media

Usually not indicated, but enhancement may be useful for delineating soft tissue lesions in selected patients.

Dose and concentration 60-100 ml, 300 mg/l/ml.
Flow rate 2-4 ml/s, preferably by power injector.
Delay and timing 40-80s depending on suspected pathology.

Modification to technique

Additional slices may be reconstructed with an appropriate FOV and algorithm to evaluate soft tissues.
The target volume may be limited or extended according to clinical indication.
**Lumbar and thoracic spine - trauma**

**Preparatory steps**

| Indication | Main indication are traumatic disorders. Similar technique can be used for bone tumours, degenerative, infectious, arthritic and osteonecrotic changes. |
| Advisable preliminary or alternative investigations | Conventional radiography; MRI or US are alternative examinations, especially in non-traumatic disorders. |
| Patient preparation | Appropriate consent. Exclude radiodense items, whenever possible. |
| Scan projection radiograph | Lumbar spine: lateral – mid chest to hip joints. Thoracic spine: frontal – thyroid cartilage to mid lumbar spine. |

**Acquisition objectives**

| Target volume | Area of lumbar or thoracic spine suspect of pathology. |
| Image weighting | Spatial resolution |
| Exposure | Exposure parameters should be adjusted to patient size, especially in paediatric patients. |
| Beam collimation | 4 slice medium (1 - 2.5 mm); 16 slice small (< 1 mm) |
| Pitch | Medium (0.9 - 1.3) |
| CTDI volume | < 15 mGy; medium (trunk phantom) |
| Tube voltage | Medium - high (110 – 130 kV; > 130 kV) |

**Image reconstruction**

- Viewing slice thickness defines exposure parameters.
- Surface reconstruction and MPR may facilitate evaluation of lesions and are recommended. This requires thin primary reconstruction section thickness.
- Adapted to beam collimation.

| Primary reconstruction section thickness | 0-50%. |
| Overlap of primary reconstruction | |
| Reconstruction algorithm | High resolution |
| Field of view | Corresponding to all cross section of the spine including adjacent muscles |
| Viewing slice thickness | Medium. |
| Overlap of viewing slices | 0 – 25%. |
Lumbar and thoracic spine - trauma

**Image quality criteria, visualization**  
1. The areas of lumbar or thoracic spine which are suspect of pathology.

**Image quality criteria, critical reproduction**  
1. Sharp reproduction of cortical bone.  
2. Sharp reproduction of trabecular bone.  
4. Sharp reproduction of the intervertebral radicular canals.  
5. Sharp reproduction of the intervertebral disk profiles.

**Contrast media**  
Usually not indicated, but enhancement may be useful for delineating soft tissue lesions in selected patients.

- **Dose and concentration**: 60-100 ml, 300 mgI/ml.
- **Flow rate**: 2-4 ml/s, preferably by power injector.
- **Delay and timing**: 40-80s depending on suspected pathology.

**Modification to technique**  
Additional slices may be reconstructed with an appropriate FOV and algorithm to evaluate soft tissues.  
The target volume may be extended according to clinical indication.
Non acute headache without known systemic diseases. Normal neurological examination.

Age
Gender

Arteriovenous malformation
Intracranial Aneurysm
Cavernous Angioma
Subdural Hematoma
Dural arteriovenous fistula
Hydrocephalus
Pituitary adenoma
Meningioma

Intracraneal Aneurysm
Outcome

Subdural Hematoma
Outcome

Dural arteriovenous fistula
Outcome

Hydrocephalus
Outcome

Meningioma
Outcome

Arnold Chiari I Outcome

Malignant glioma
Outcome

Low grade Astrocytoma

Disease Effects

Neoplasm markers

Dose
Anatomic region
Induced cancer
Radiated organs
Future Effects
Health Effects

Patient Risk

Imaging Policy

Do Imaging

Imaging Effects

Test Done

Do Treatment

Treatment Policy