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

End date of phase III: 31st December 2007
Version 1.2
Submission date of final version: 15th February 2008

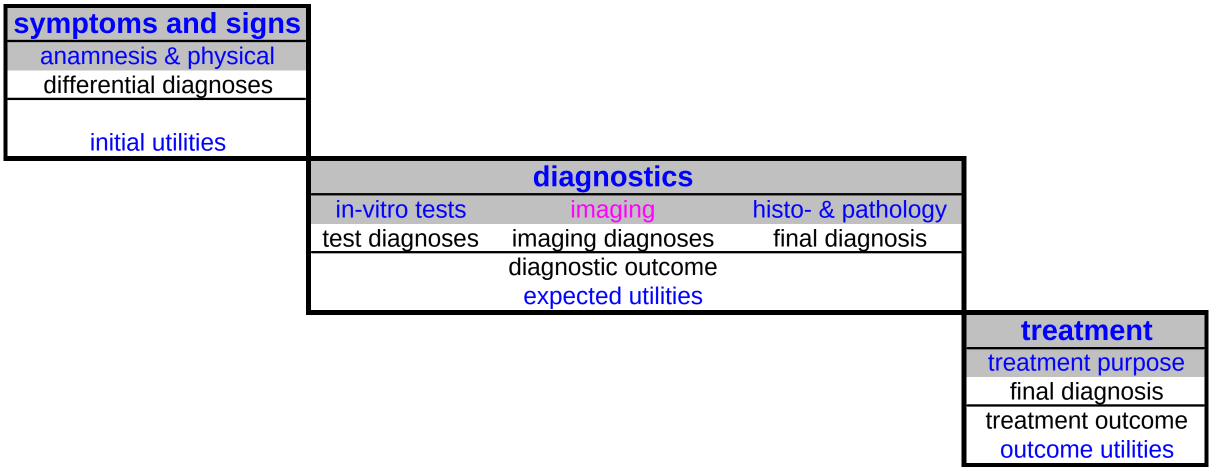
Start date of project: 01-01-2005 Duration: 36 months

Leiden University Medical Centre, Leiden, The Netherlands
Aarhus University Hospital, Aarhus, Denmark
Complutense University, Madrid, Spain
University Hospital Basel, Basel, Switzerland
University of Crete, Iraklion, Crete, Greece
University of Oxford, Oxford, UK

Table of contents

I Justification

The medical process



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

ICD10	head and neck	thorax	abdomen	shoulder, hip
2 Neoplasms	nonacute headache		testis cancer: retroperitoneal spread (AUH)	
6 Diseases of the nervous system	nonacute headache (UCM); mild head trauma (LUMC)			
9 Diseases of the circulatory system	nonacute headache	acute chest pain: coronary artery diseases (LUMC); pulmonary embolism (UHBS)		
11 Diseases of the digestive system			acute abdominal pain: appendicitis (LUMC); abdominal sepsis (UOXF)	
13 Diseases of the musculoskeletal system and connective tissue	cervical-spine trauma (UoC)		low back pain (UCM)	sterno-clavicular joint imaging (AUH)
14 Diseases of the genitourinary system			haematuria: urothelial cancer (UoC); acute flank pain: urolithiasis (UHBS)	

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.

Model
Acute chest pain

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.

Model
SternoclavicularJoint

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 Béliz, 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

Indication	Traumatic lesions of the brain. Suspected or known focal or diffuse structural disease when MRI is contra-indicated or not available.
Advisable preliminary or alternative investigations	Clinical neurological examination. MRI is an alternative examination without exposure to ionising radiation.
Patient preparation	Appropriate consent. Exclude radiodense items, whenever possible.
Scan projection radiograph	Lateral: skull base to vertex.

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 mgI/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 gastro-intestinal 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) 6. Reproduction of vessels in the liver (unenhanced slices: veins)
Contrast media	Enhancement may increase sensitivity and specificity.
Dose and concentration	80-120ml, 300mg I/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	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.
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. 3. Sharp reproduction of the intervertebral joints. 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 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.

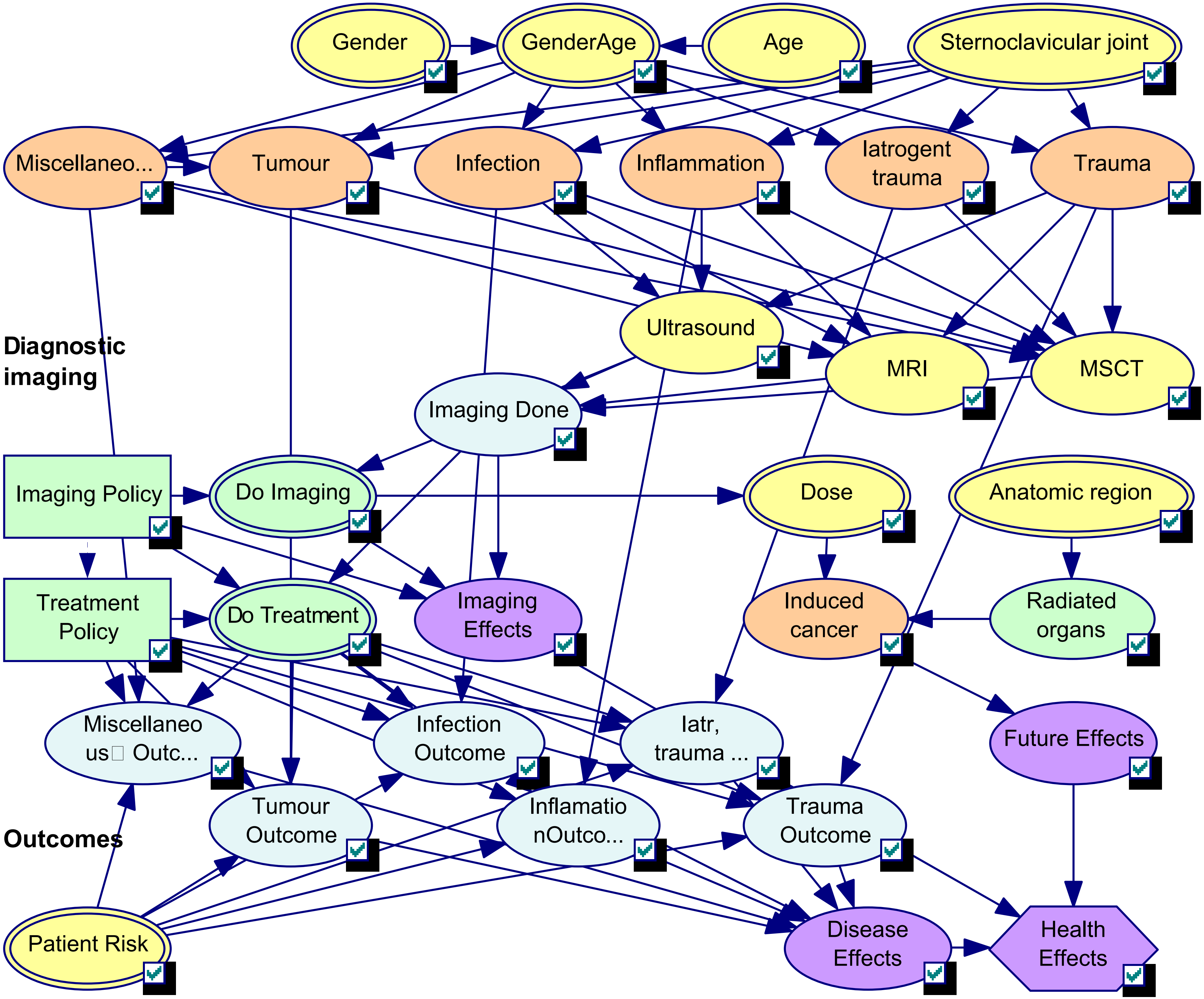
Acquisition objectives

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)

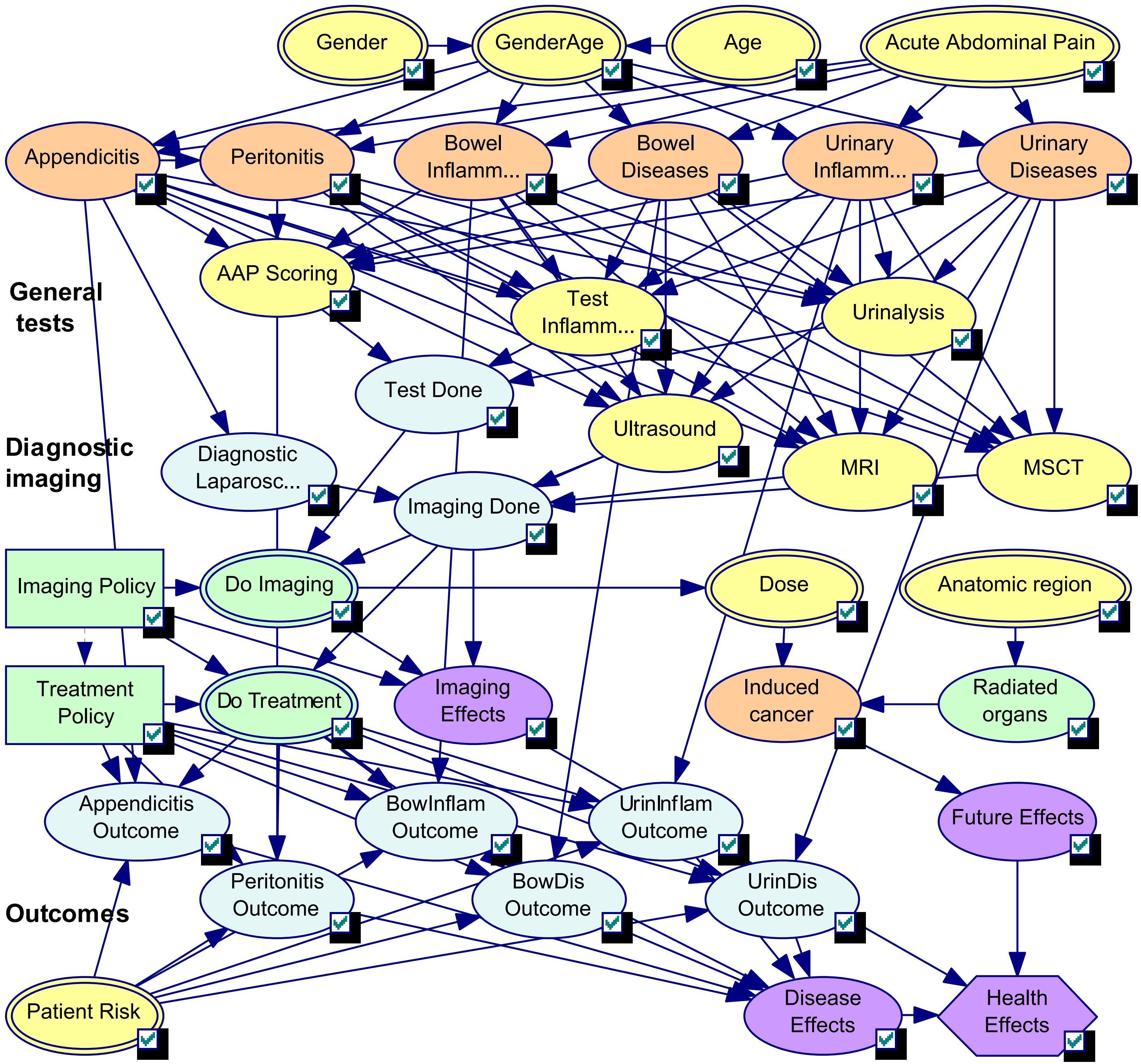
Image reconstruction	Viewing slice thickness defines exposure parameters. Surface reconstruction and MPR may facilitate evaluation of lesions and are recommended. This requires thin primary reconstruction section thickness.
Primary reconstruction section thickness	Adapted to beam collimation.
Overlap 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.
Overlap of viewing slices	0 – 25%.

Lumbar and thoracic spine - trauma

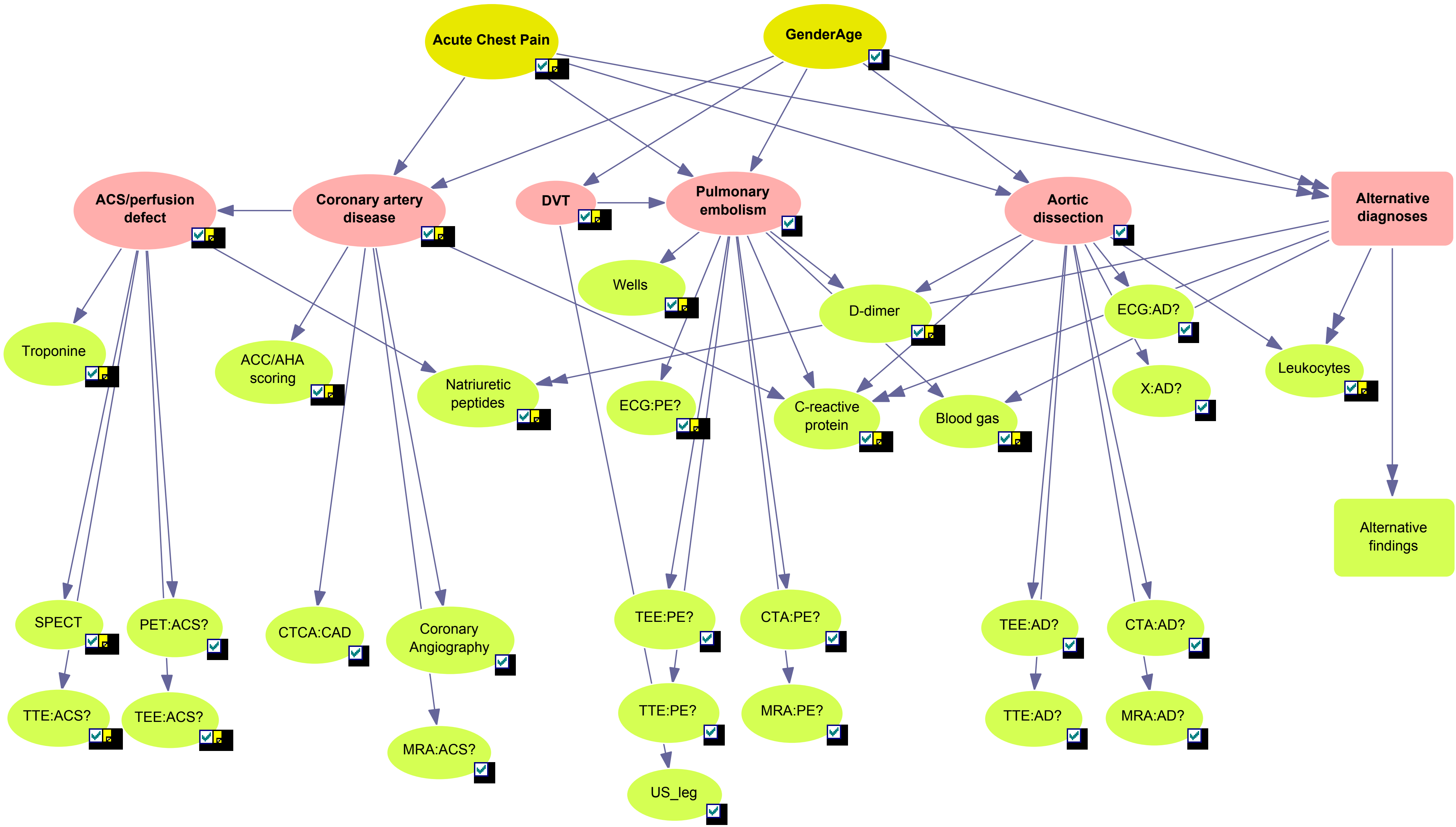
Image quality criteria, visualization	1. The areas of lumbar or thoracic spine which are suspect of pathology.
Image quality criteria, critical reproduction	1. Sharp reproduction of cortical bone. 2. Sharp reproduction of trabecular bone. 3. Sharp reproduction of the intervertebral joints. 4. Sharp reproduction 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.



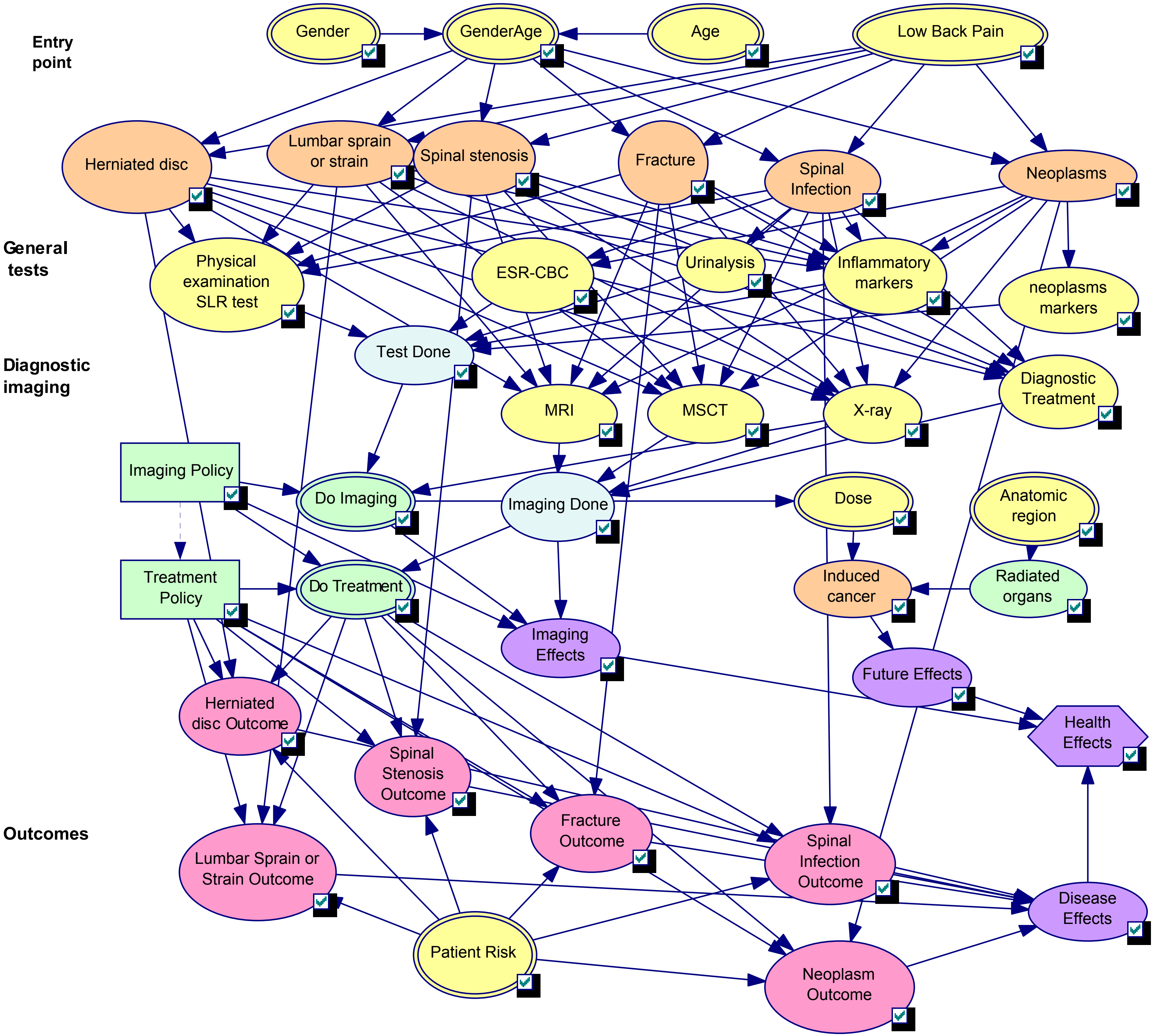
Gender
GenderAge
Age
Sternoclavicular joint
Miscellaneo...
Tumour
Infection
Inflammation
Iatrogent trauma
Trauma
Ultrasound
MRI
MSCT
Diagnostic imaging
Imaging Done
Imaging Policy
Do Imaging
Dose
Anatomic region
Treatment Policy
Do Treatment
Imaging Effects
Induced cancer
Radiated organs
Miscellaneo us Outc...
Infection Outcome
Iatr, trauma ...
Future Effects
Tumour Outcome
Inflamatio nOutco...
Trauma Outcome
Outcomes
Patient Risk
Disease Effects
Health Effects



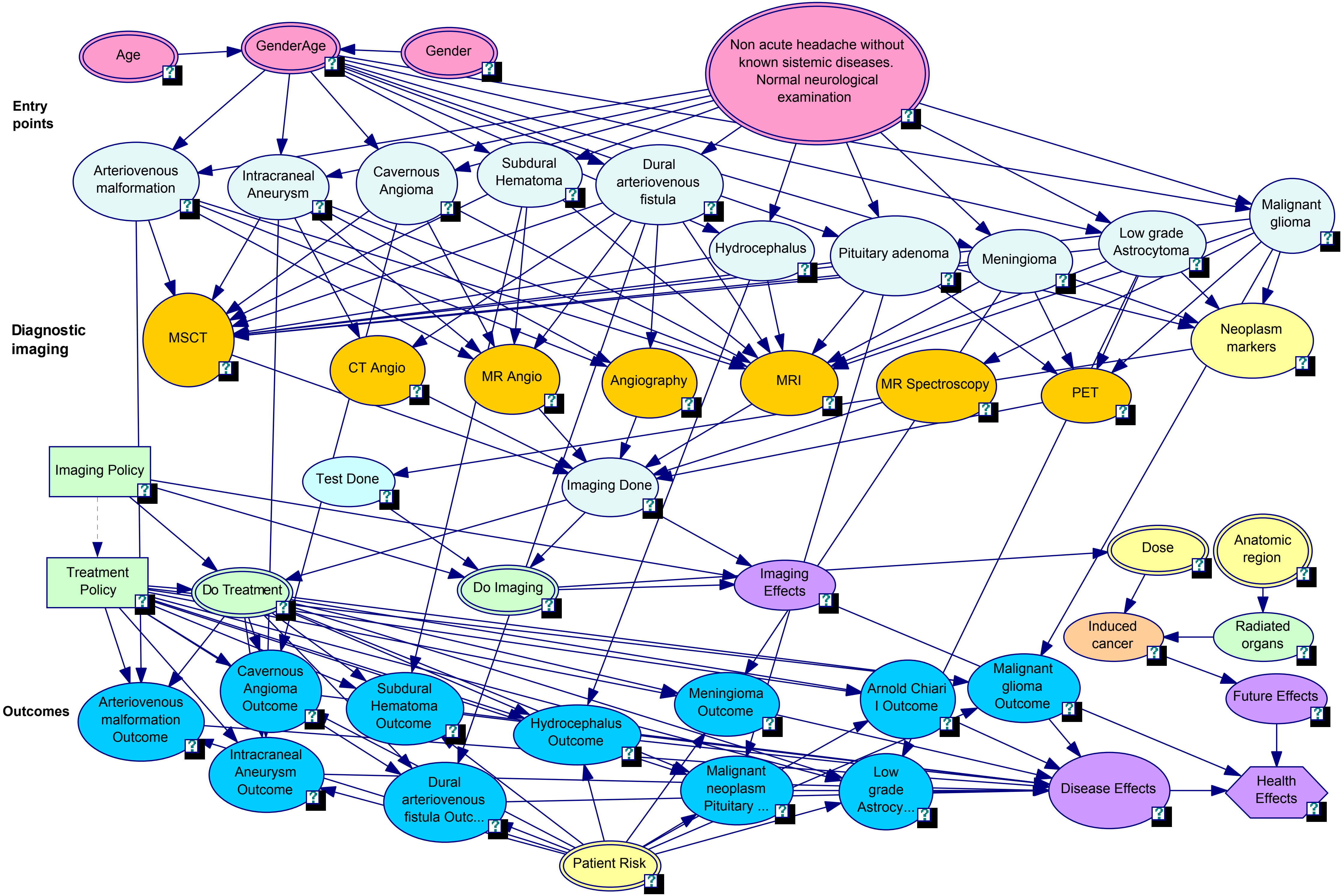
Gender
GenderAge
Age
Acute Abdominal Pain
Appendicitis
Peritonitis
Bowel Inflamm...
Bowel Diseases
Urinary Inflamm...
Urinary Diseases
General tests
AAP Scoring
Test Inflamm...
Urinalysis
Test Done
Diagnostic imaging
Diagnostic Laparosc...
Ultrasound
MRI
MSCT
Imaging Done
Imaging Policy
Do Imaging
Dose
Anatomic region
Treatment Policy
Do Treatment
Imaging Effects
Induced cancer
Radiated organs
Appendicitis Outcome
BowInflam Outcome
UrinInflam Outcome
Future Effects
Peritonitis Outcome
BowDis Outcome
UrinDis Outcome
Outcomes
Patient Risk
Disease Effects
Health Effects



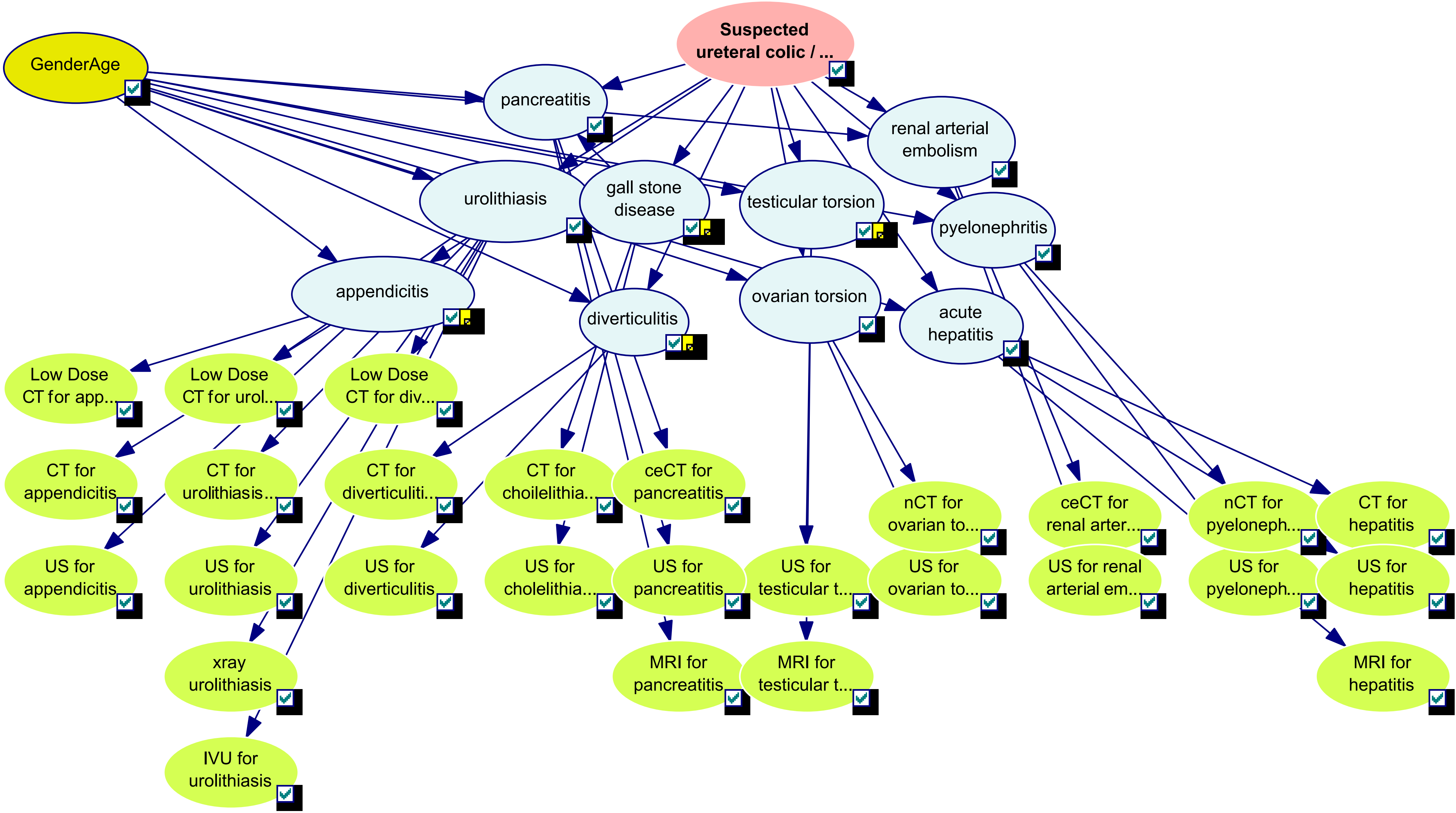
Acute Chest Pain
GenderAge
ACS/perfusion defect
Coronary artery disease
DVT
Pulmonary embolism
Aortic dissection
Alternative diagnoses
Wells
D-dimer
ECG:AD?
Troponine
ACC/AHA scoring
Natriuretic peptides
ECG:PE?
C-reactive protein
Blood gas
X:AD?
Leukocytes
Alternative findings
SPECT
PET:ACS?
CTCA:CAD
Coronary Angiography
TEE:PE?
CTA:PE?
TEE:AD?
CTA:AD?
TTE:ACS?
TEE:ACS?
MRA:ACS?
TTE:PE?
MRA:PE?
TTE:AD?
MRA:AD?
US_leg



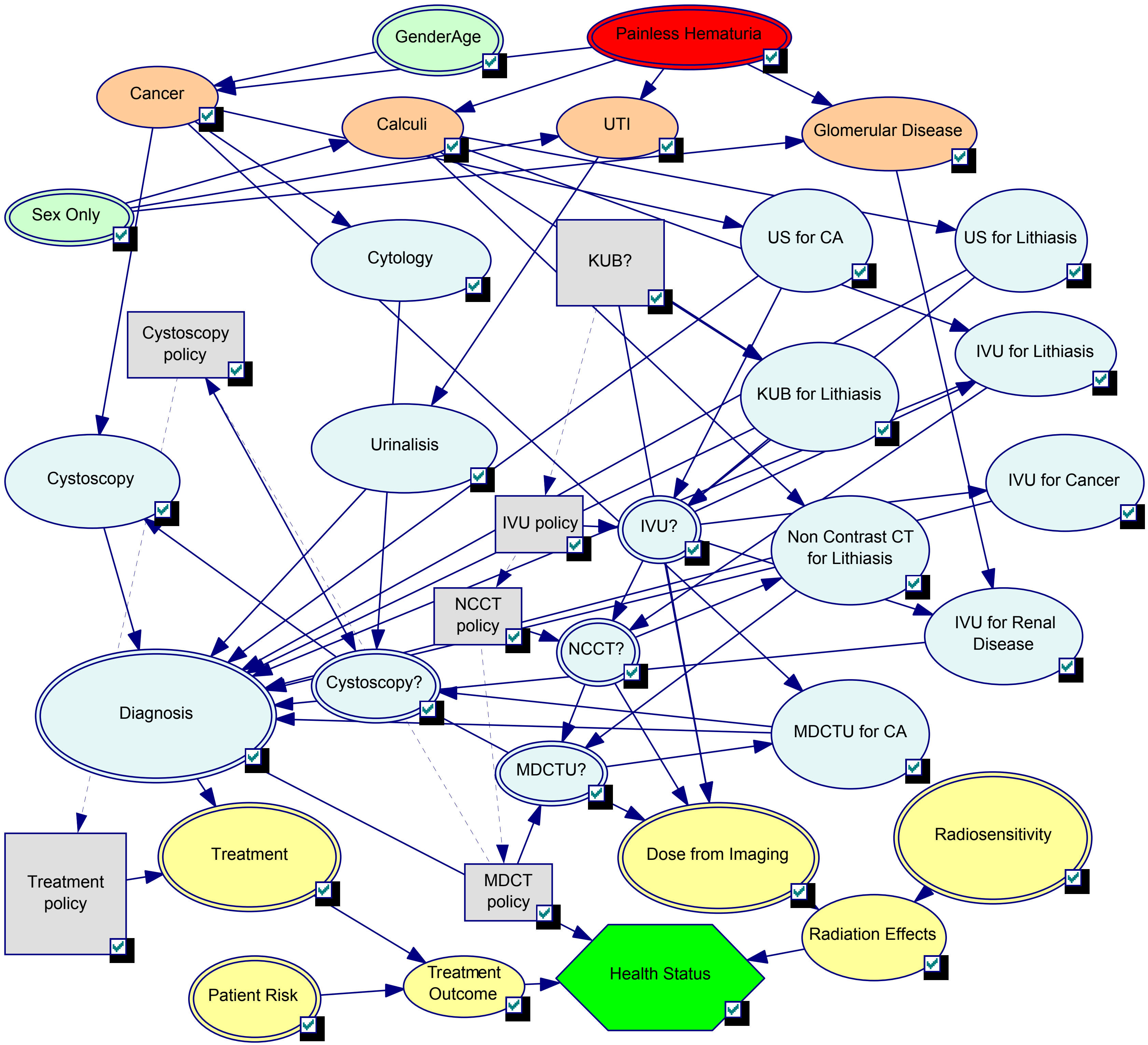
Entry point
General tests
Diagnostic imaging
Outcomes
Gender
GenderAge
Age
Low Back Pain
Herniated disc
Lumbar sprain or strain
Spinal stenosis
Fracture
Spinal Infection
Neoplasms
Physical examination SLR test
ESR-CBC
Urinalysis
Inflammatory markers
neoplasms markers
Test Done
MRI
MSCT
X-ray
Diagnostic Treatment
Imaging Policy
Do Imaging
Imaging Done
Dose
Anatomic region
Treatment Policy
Do Treatment
Induced cancer
Radiated organs
Imaging Effects
Future Effects
Health Effects
Herniated disc Outcome
Spinal Stenosis Outcome
Fracture Outcome
Spinal Infection Outcome
Disease Effects
Lumbar Sprain or Strain Outcome
Patient Risk
Neoplasm Outcome



Age
GenderAge
Gender
Non acute headache without known sistemic diseases. Normal neurological examination
Entry points
Arteriovenous malformation
Intracraneal Aneurysm
Cavernous Angioma
Subdural Hematoma
Dural arteriovenous fistula
Hydrocephalus
Pituitary adenoma
Meningioma
Low grade Astrocytoma
Malignant glioma
Diagnostic imaging
MSCT
CT Angio
MR Angio
Angiography
MRI
MR Spectroscopy
PET
Neoplasm markers
Imaging Policy
Test Done
Imaging Done
Treatment Policy
Do Treatment
Do Imaging
Imaging Effects
Dose
Anatomic region
Induced cancer
Radiated organs
Future Effects
Outcomes
Arteriovenous malformation Outcome
Cavernous Angioma Outcome
Intracraneal Aneurysm Outcome
Subdural Hematoma Outcome
Dural arteriovenous fistula Outc...
Hydrocephalus Outcome
Meningioma Outcome
Malignant neoplasm Pituitary ...
Arnold Chiari I Outcome
Low grade Astrocy...
Malignant glioma Outcome
Disease Effects
Health Effects
Patient Risk



GenderAge
Suspected ureteral colic / ...
pancreatitis
renal arterial embolism
urolithiasis
gall stone disease
testicular torsion
pyelonephritis
appendicitis
diverticulitis
ovarian torsion
acute hepatitis
Low Dose CT for app...
Low Dose CT for urol...
Low Dose CT for div...
CT for appendicitis
CT for urolithiasis...
CT for diverticuliti...
CT for choilelithia...
ceCT for pancreatitis
nCT for ovarian to...
ceCT for renal arter...
nCT for pyeloneph...
CT for hepatitis
US for appendicitis
US for urolithiasis
US for diverticulitis
US for cholelithia...
US for pancreatitis
US for testicular t...
US for ovarian to...
US for renal arterial em...
US for pyeloneph...
US for hepatitis
xray urolithiasis
MRI for pancreatitis
MRI for testicular t...
MRI for hepatitis
IVU for urolithiasis


GenderAge
Painless Hematuria
Cancer
Calculi
UTI
Glomerular Disease
Sex Only
Cytology
KUB?
US for CA
US for Lithiasis
Cystoscopy
policy
IVU for Lithiasis
KUB for Lithiasis
Urinalisis
Cystoscopy
IVU for Cancer
IVU policy
IVU?
Non Contrast CT
for Lithiasis
NCCT
policy
IVU for Renal
Disease
NCCT?
Cystoscopy?
Diagnosis
MDCTU for CA
MDCTU?
Radiosensitivity
Treatment
Dose from Imaging
Treatment
policy
MDCT
policy
Radiation Effects
Health Status
Patient Risk
Treatment
Outcome