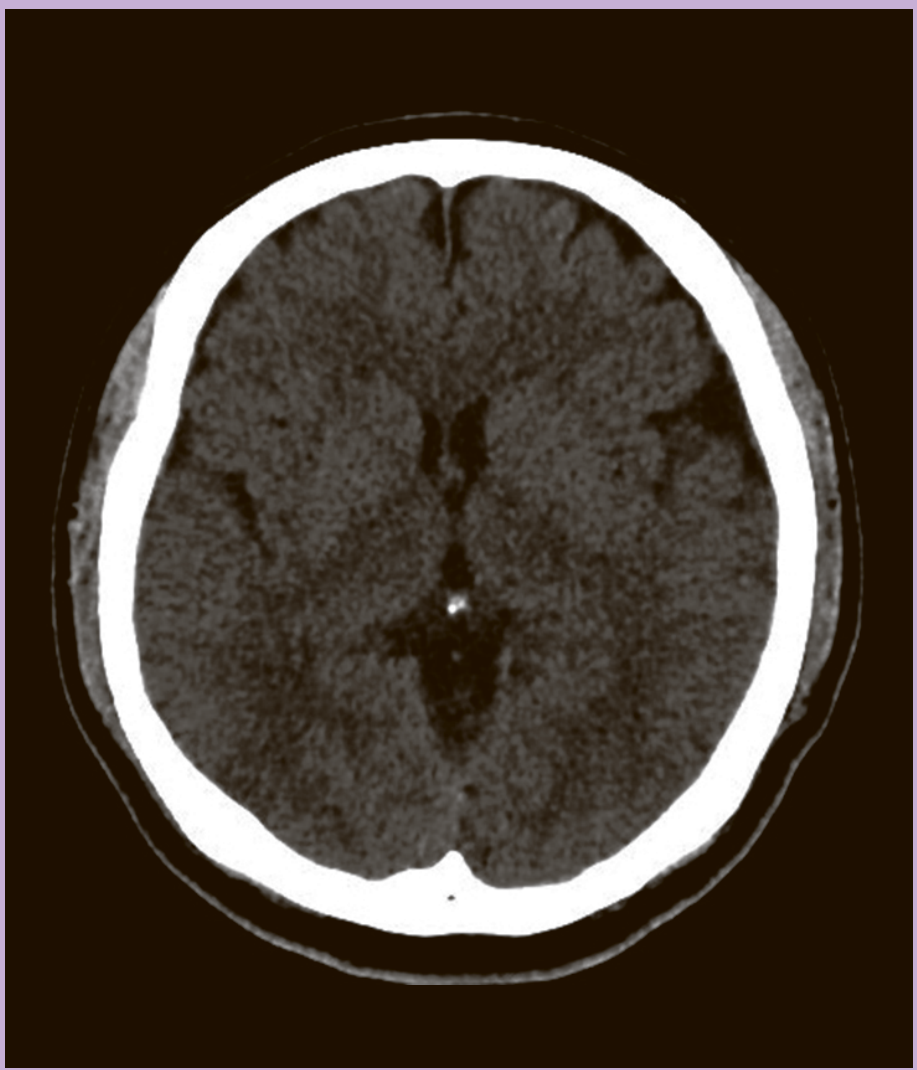
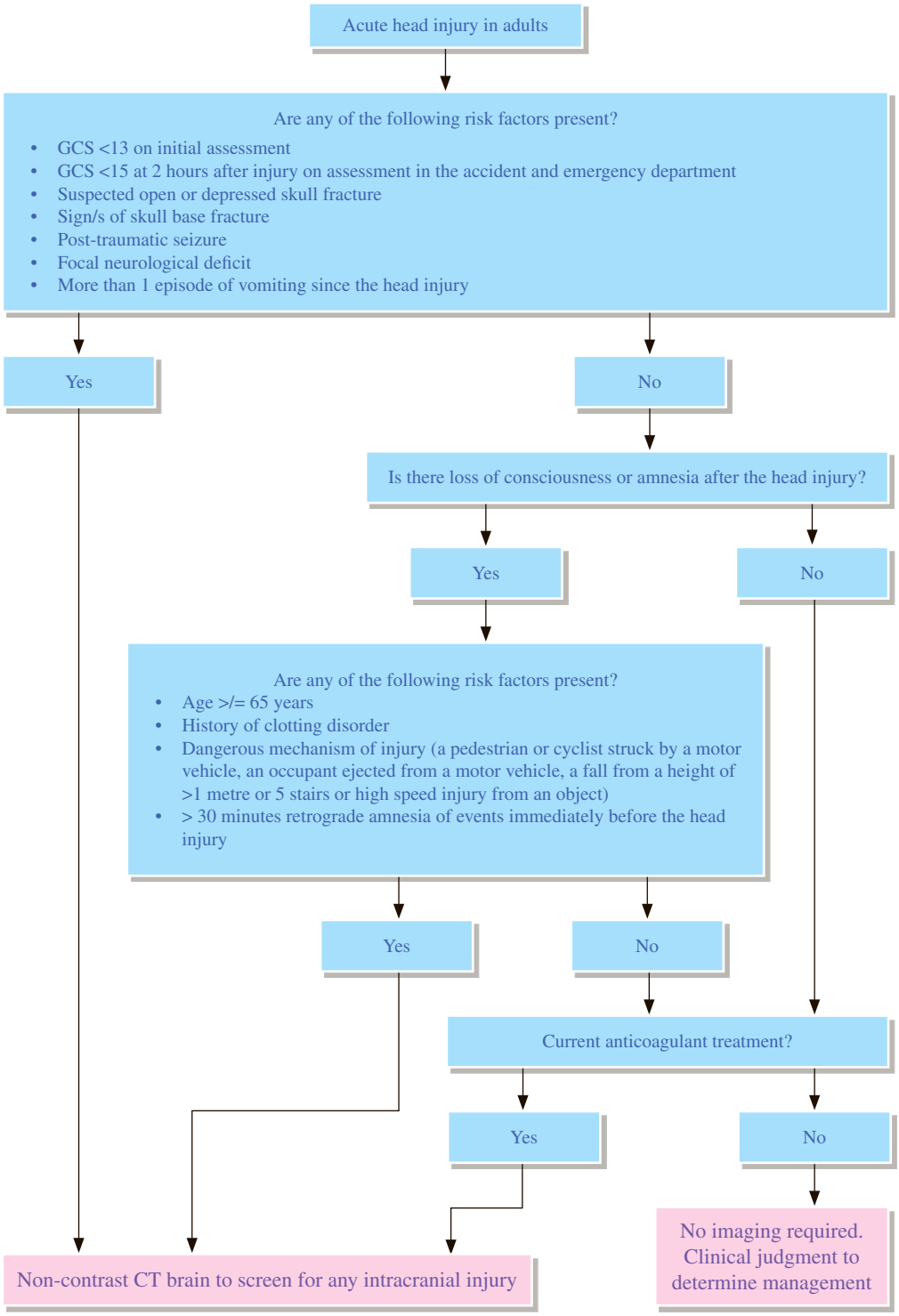
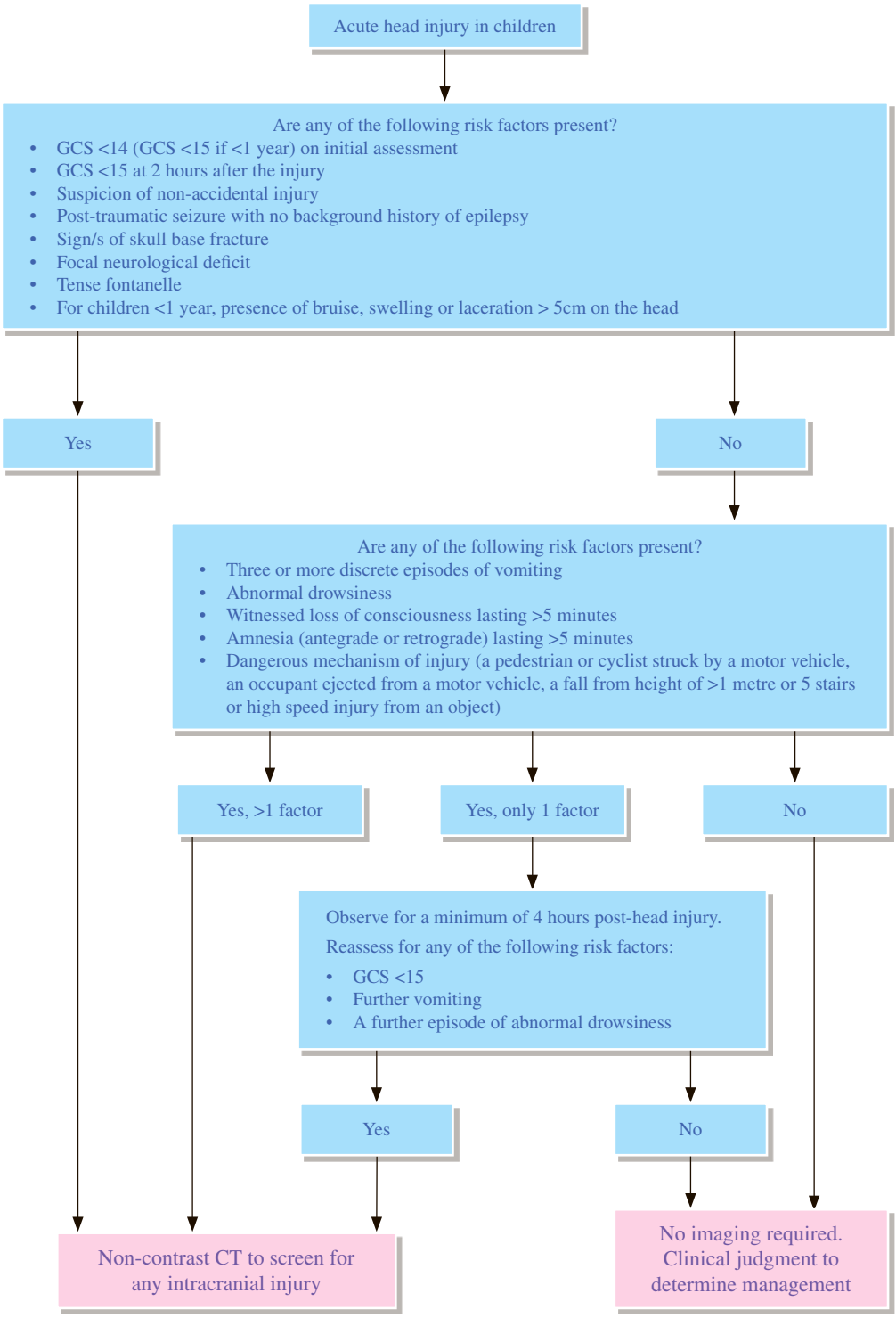
Neuroradiology



Hong Kong College of Radiologists


Acute head injury in adults
Are any of the following risk factors present?
• GCS <13 on initial assessment
• GCS <15 at 2 hours after injury on assessment in the accident and emergency department
• Suspected open or depressed skull fracture
• Sign/s of skull base fracture
• Post-traumatic seizure
• Focal neurological deficit
• More than 1 episode of vomiting since the head injury
Yes
No
Is there loss of consciousness or amnesia after the head injury?
Yes
No
Are any of the following risk factors present?
• Age >/= 65 years
• History of clotting disorder
• Dangerous mechanism of injury (a pedestrian or cyclist struck by a motor vehicle, an occupant ejected from a motor vehicle, a fall from a height of >1 metre or 5 stairs or high speed injury from an object)
• > 30 minutes retrograde amnesia of events immediately before the head injury
Yes
No
Current anticoagulant treatment?
Yes
No
Non-contrast CT brain to screen for any intracranial injury
No imaging required. Clinical judgment to determine management


Acute head injury in children
Are any of the following risk factors present?
• GCS <14 (GCS <15 if <1 year) on initial assessment
• GCS <15 at 2 hours after the injury
• Suspicion of non-accidental injury
• Post-traumatic seizure with no background history of epilepsy
• Sign/s of skull base fracture
• Focal neurological deficit
• Tense fontanelle
• For children <1 year, presence of bruise, swelling or laceration > 5cm on the head
Yes
No
Are any of the following risk factors present?
• Three or more discrete episodes of vomiting
• Abnormal drowsiness
• Witnessed loss of consciousness lasting >5 minutes
• Amnesia (antegrade or retrograde) lasting >5 minutes
• Dangerous mechanism of injury (a pedestrian or cyclist struck by a motor vehicle, an occupant ejected from a motor vehicle, a fall from height of >1 metre or 5 stairs or high speed injury from an object)
Yes, >1 factor
Yes, only 1 factor
No
Observe for a minimum of 4 hours post-head injury.
Reassess for any of the following risk factors:
• GCS <15
• Further vomiting
• A further episode of abnormal drowsiness
Yes
No
Non-contrast CT to screen for any intracranial injury
No imaging required. Clinical judgment to determine management

REMARKS

1 General

1.1 It is the clinical condition of the patient that determines whether imaging is required or not.

1.2 Patients discharged from accident and emergency department after head injury should be given advice in verbal and written formats, which is also to be shared with their families and carers.

2 Plain radiograph

2.1 Normal skull x-ray (SXR) does not exclude intracranial pathology.

2.2 SXR is only useful for imaging for calvarial fractures, penetrating injuries and suspected radio-opaque foreign bodies.

3 CT

3.1 Non-contrast CT scan is the imaging modality of choice in evaluating head trauma.

3.2 In most cases, CT alone is sufficient to end the diagnostic imaging work up.

3.3 Early and repeated CT scanning may be required for further evaluation when there is deterioration (especially in the first 72 hours after head injury), to detect delayed haematoma, hypoxic-ischaemic lesions or cerebral oedema.

4 MRI

4.1 MRI is inappropriate as first line study in acute head trauma.

4.2 MRI is valuable as a problem solving tool in selected cases, such as in the following settings:

- 4.2.1 Hypoxic-ischaemic encephalopathy
- 4.2.2 Brain stem contusion (haemorrhagic / non-haemorrhagic)
- 4.2.3 Diffuse axonal injury
- 4.2.4 Small subdural haematoma

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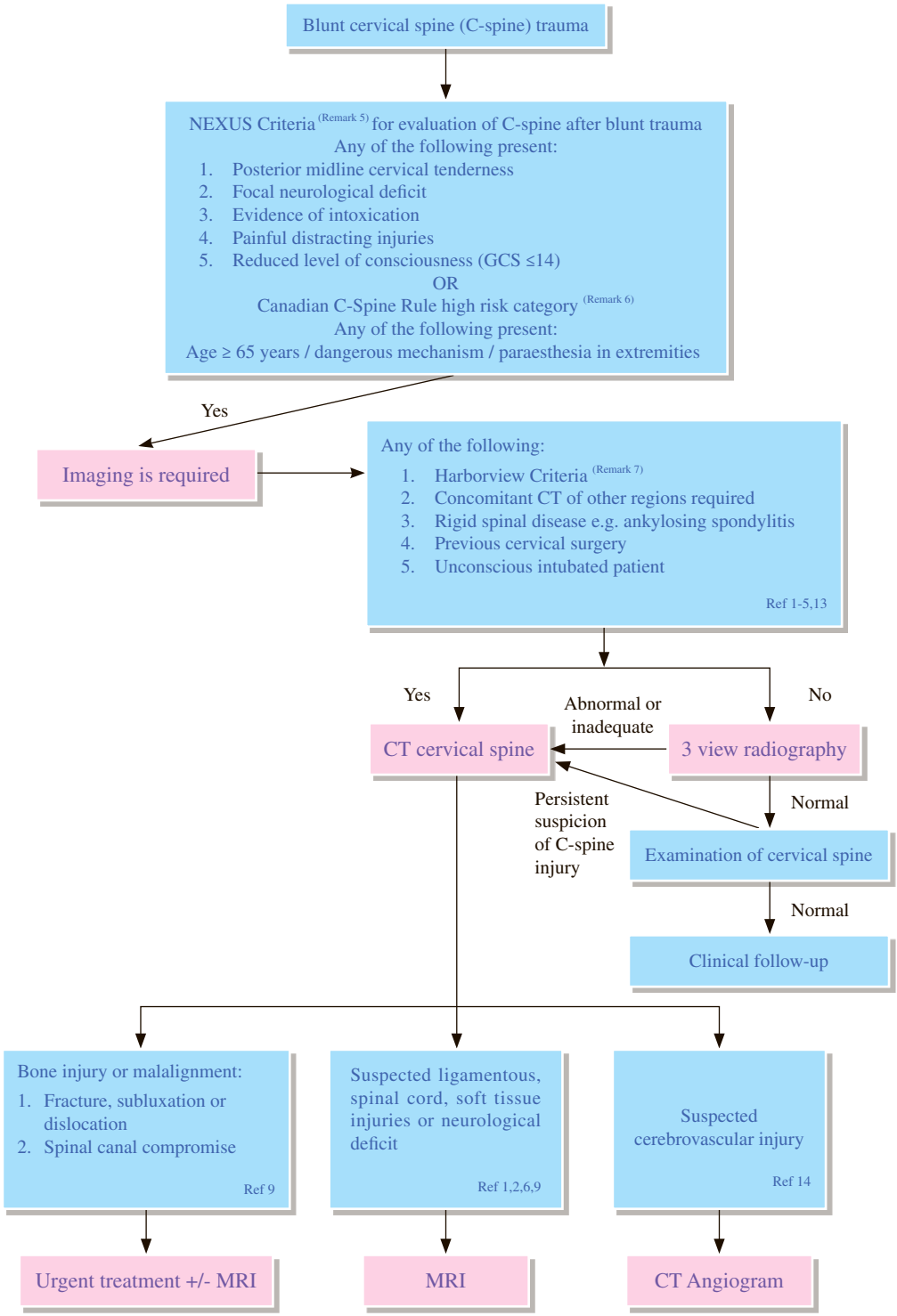
NR 2 Blunt cervical spine trauma



REMARKS

1 General

1.1 The imaging pathways in the algorithm are not mutually exclusive with each other and the use of the pathway should be guided by clinical suspicion.

2 Plain radiograph

2.1 Anteroposterior, lateral and open mouth views of the cervical spine are the basic views. It is essential that all seven cervical vertebrae are visualized including the cervicothoracic junction and the craniocervical junction.

2.2 Flexion-extension radiography is not useful in the acute injury period because of muscle spasm.[6]

2.3 It has advantages of lower radiation dose than CT which is important in younger patients.[7] It is cheaper than CT, but cost-effectiveness must take into account the massive costs associated with even one missed fracture that results in spinal cord injury.[7,8]

2.4 These limitations and the potential morbidity associated with missed fractures have led to a change in recommendations in preference to CT.[1,8]

3 CT

3.1 CT with multiplanar reformats is highly sensitive and specific and superior to radiography in the detection of cervical spine injury in both alert and obtunded patients, or in patients who cannot be evaluated with plain radiography.[9,10]

3.2 Useful in evaluation of bony displacement and in pre-operative planning.[11]

4 MRI

4.1 Imaging modality of choice for evaluating ligamentous, spinal cord and soft tissue injuries, or for patients with neurological deficits not explained by plain film or CT findings, and for patients with injuries requiring posterior stabilization so as to exclude concomitant disc herniations that might alter the surgical approach.[12]

4.2 In trauma patients with ankylosing spondylitis, routine CT and MR imaging is recommended, even after minor trauma.[13]

5 National Emergency X-Radiography Utilization Study (NEXUS) Criteria

5.1 Any of the following

5.1.1 Posterior midline cervical tenderness

5.1.2 Focal neurological deficits

5.1.3 Evidence of intoxication

5.1.4 Painful distracting injuries

5.1.5 Reduced level of consciousness (GCS ≤14)

6 Canadian C-Spine Rule

6.1 High-risk factors that mandate radiography: age ≥ 65 years, dangerous mechanism (i.e. fall from ≥1 metre / 5 stairs; axial load to head e.g. diving; high speed (>100 km/h) motor vehicle collision; motorized recreational vehicles; bicycle collision), or paraesthesia in extremities.

7 Harborview Criteria

7.1 Any of the following:

- 7.1.1 Presence of significant head injury
- 7.1.2 Presence of focal neurological deficit
- 7.1.3 Presence of pelvic or multiple extremity fractures
- 7.1.4 Combined impact of accident >50km/h
- 7.1.5 Death at the scene of the motor vehicle accident
- 7.1.6 Accident involved a fall from a height of 3m or more

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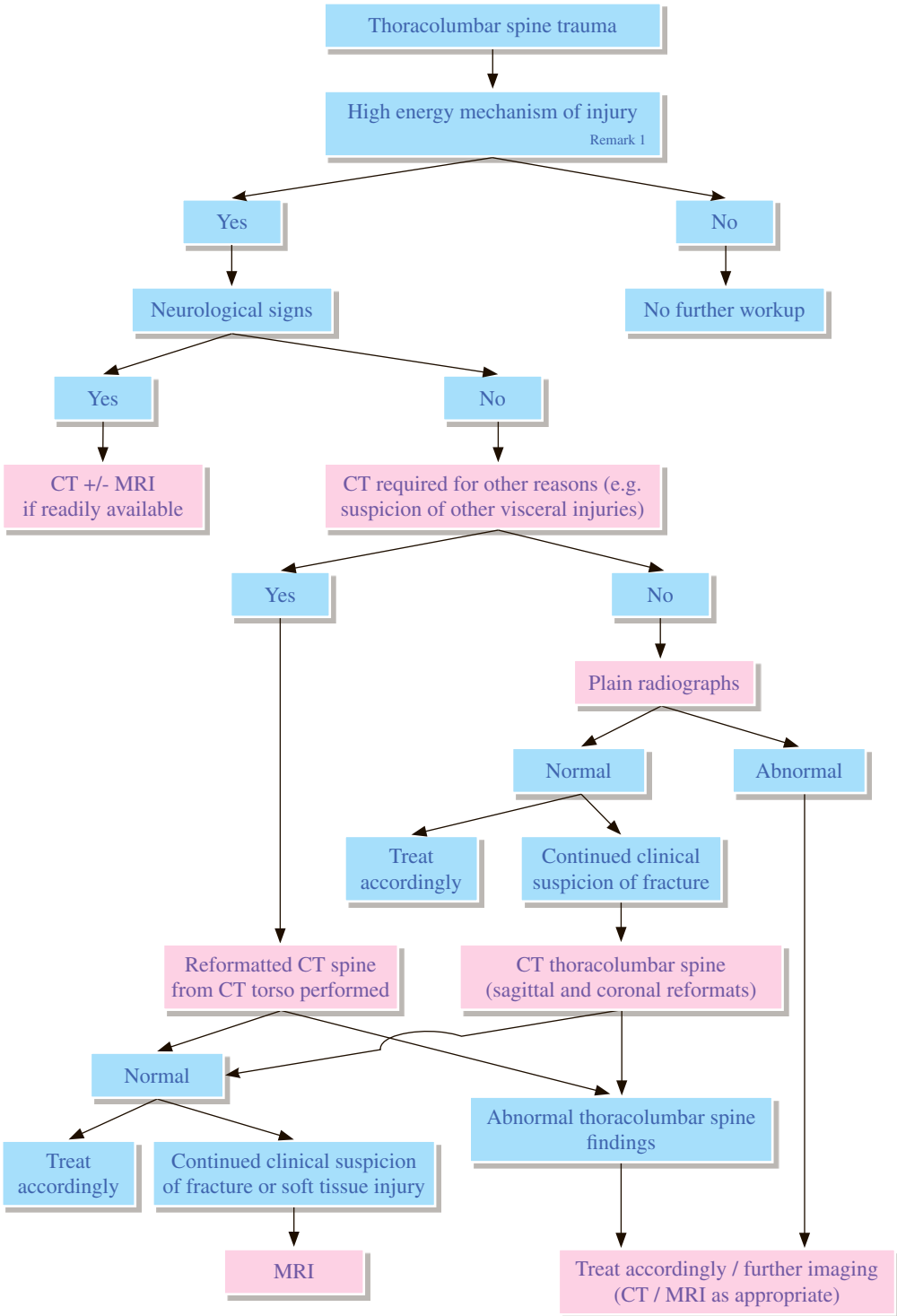
NR 3 Thoracolumbar spine trauma



REMARKS

1 General

1.1 Radiological workup is indicated for cases with high energy mechanism of injury including:
History of significant mechanism of injury such as high impact motor vehicle accident or fall from a height >1 metre, concomitant cervical spine fracture, back pain or tenderness on palpation, local signs of thoracolumbar injury, neurological deficits, altered mental status, major distracting injuries, evidence of intoxication with ethanol or drugs.[1,3-6]

1.2 Approximately 20% of patients with a spinal column fracture will have a non-contiguous fracture. Non-contiguous fractures are associated with other severe injuries and should be suspected and investigated in injuries involving high-velocity mechanisms.[2,8]

2 Plain radiograph

2.1 Plain films are considered adequate for the evaluation of thoracolumbar spine if the patient does not require CT scan for any other reason.[1, 3- 4, 6]

3 CT

3.1 CT is excellent in imaging bony fractures. In patients who undergo torso CT (thorax, abdomen and pelvis), the images will be adequate to evaluate the spine with sagittal and coronal reformats.[2-3, 7]

4 MRI

4.1 MRI should be performed if there is clinical concern for cord compression or ligamentous instability, as well as when clinical suspicion is high for an unstable injury despite normal radiographic evaluation.

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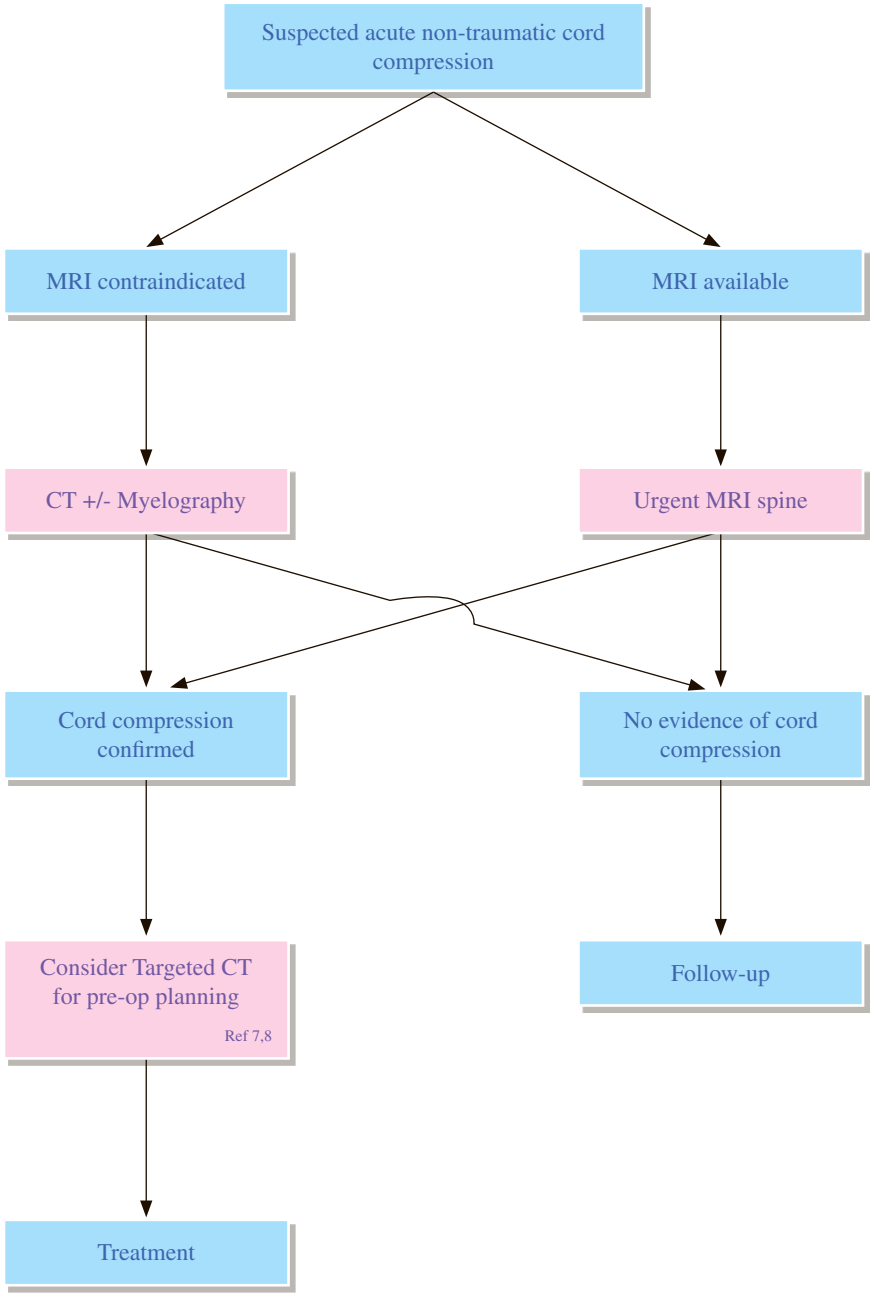
NR 4 Acute non-traumatic spinal cord compression



REMARKS

1 General

1.1 Cord compression is to be suspected when there is presence of motor deficit or sensory disturbance. Though pain is a common symptom, it is not an essential feature of cord compression.[5,6]

1.2 Do not perform plain radiographs of the spine either to make or to exclude the diagnosis of spinal metastases or metastatic spinal cord compression (MSCC).[7,8]

1.3 MRI of the spine should be performed in all patients with suspected MSCC, unless contraindicated.[7,8]

1.4 MRI of the whole spine in patients with suspected MSCC should include sagittal T1, and / or short T1 inversion recovery (STIR) and sagittal T2 weighted sequences. Perform supplementary axial imaging through any significant abnormality noted on the sagittal scan.[7-9]

1.5 Consider targeted CT scan with 3-plane reformats to assess spinal stability and plan vertebroplasty, kyphoplasty or spinal surgery in patients with MSCC.[8,9]

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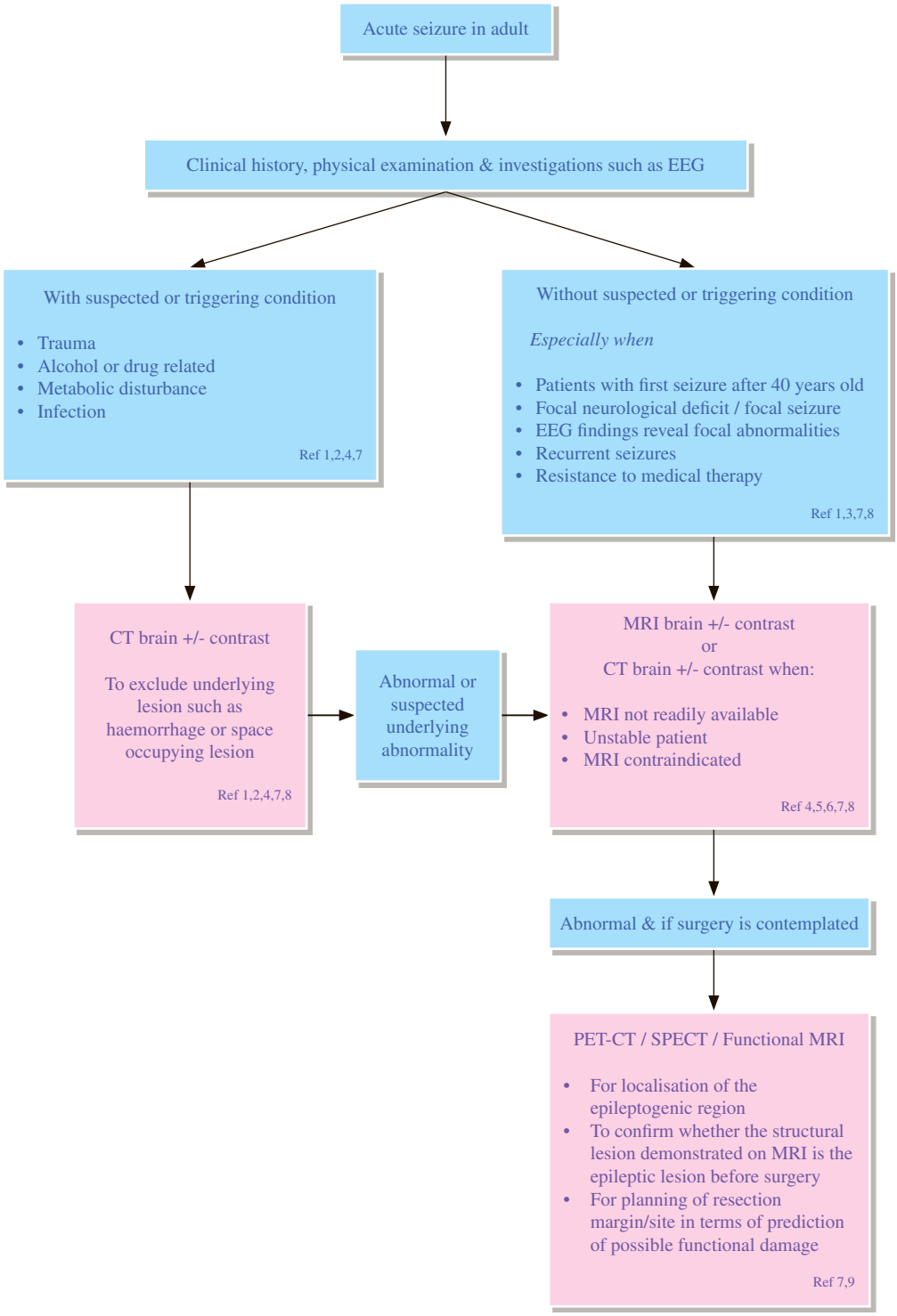
NR 5 Acute seizure in adult



REMARKS

Imaging is not indicated in idiopathic generalized epilepsy.

1 Plain radiograph

1.1 Skull x-ray (SXR) is generally not indicated in the investigation of seizure.

2 Nuclear medicine

2.1 Combined data from interictal and ictal single photon emission computed tomography (SPECT) scans give a lot more information than interictal scans alone.

2.2 Fluorodeoxyglucose (FDG) PET has high sensitivity and specificity in localizing the epileptogenic zone, especially in temporal lobe epilepsy.

2.3 Both SPECT and FDG PET-CT may be helpful in pre-operative planning.

3 CT

3.1 In acute or emergency setting, non-contrast CT brain can be the imaging study of choice.

3.2 CT is useful to detect intracranial haemorrhage or calcific lesion.

3.3 CT is an appropriate investigation if MRI is not readily available, in patients with unstable conditions or when MRI is contraindicated.

3.4 Contrast-enhanced examination should be performed if intracranial infection, tumour, inflammatory lesion or vascular pathology is suspected.

4 MRI

4.1 MRI is preferable to CT as the first imaging investigation in clinically stable and/or symptomatic patients due to its high sensitivity to small change in tissue, e.g. migrational anomalies, gyral malformations, etc.

4.2 In unstable patients, MRI is relatively contraindicated and needs close monitoring.

4.3 Coronal MRI is helpful to lateralize the temporal lobe seizure focus.

4.4 High resolution MRI sequences are preferred.

4.5 Contrast-enhanced examination should be performed if intracranial infection, tumour, inflammatory lesion or vascular pathology is suspected.

4.6 Functional MRI maybe helpful in pre-operative planning.

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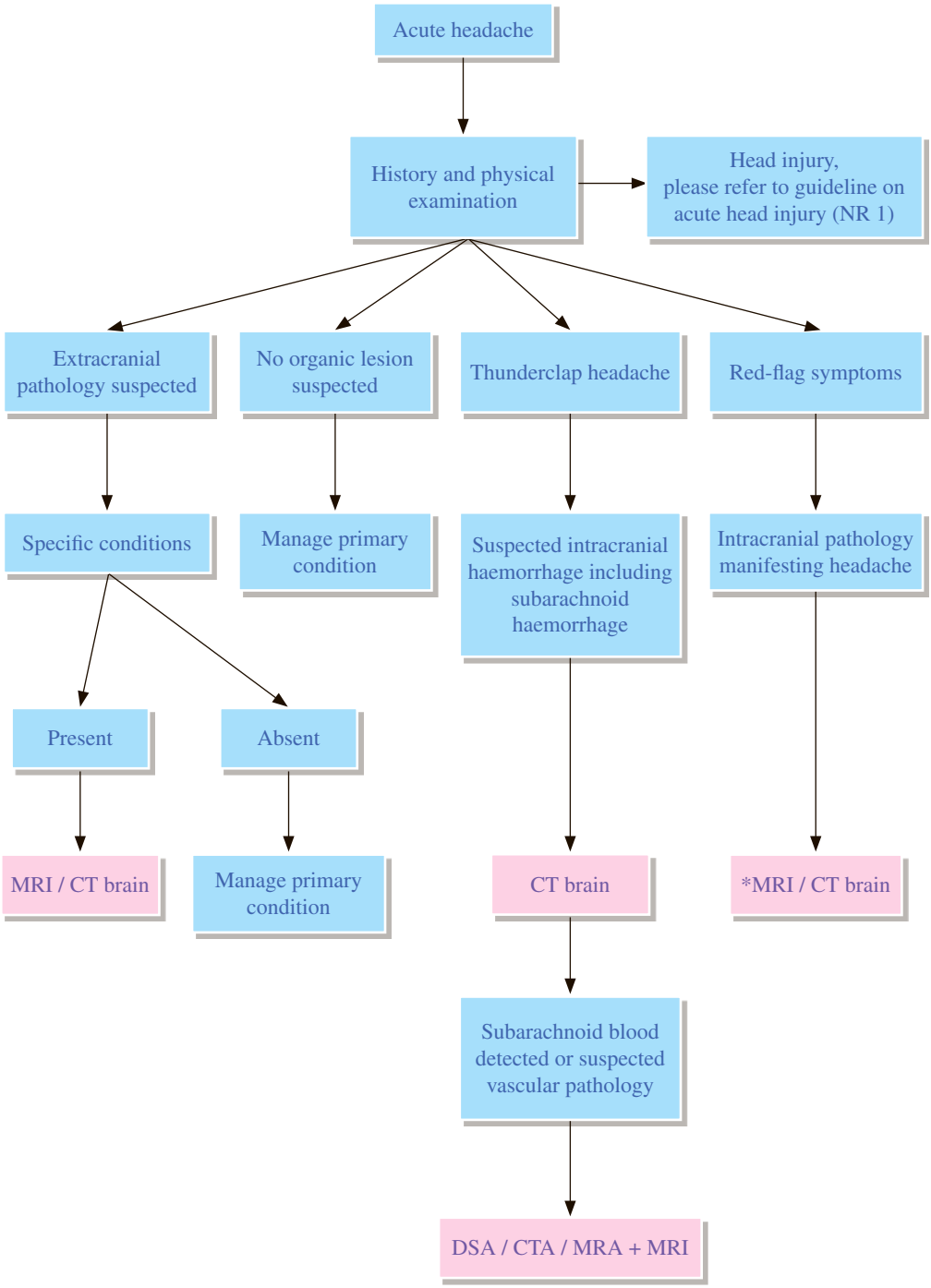
Acute headache
History and physical examination
Head injury, please refer to guideline on acute head injury (NR 1)
Extracranial pathology suspected
No organic lesion suspected
Thunderclap headache
Red-flag symptoms
Specific conditions
Manage primary condition
Suspected intracranial haemorrhage including subarachnoid haemorrhage
Intracranial pathology manifesting headache
Present
Absent
MRI / CT brain
Manage primary condition
CT brain
*MRI / CT brain
Subarachnoid blood detected or suspected vascular pathology
DSA / CTA / MRA + MRI

REMARKS

1 General

1.1 Thunderclap headache refers to acute onset of the worst headache in the individual's life.

1.2 Primary headache disorders include migraine, tension and cluster headache. However, a change in the pattern of the headache should raise the concern of a superimposed organic lesion.

1.3 Red flag symptoms raise the suspicion of organic lesions, including:

- 1.3.1 New headache in an older population
- 1.3.2 New onset of headache with history of cancer or immunodeficiency
- 1.3.3 New onset of headache in a patient on anti-coagulation therapy
- 1.3.4 Headache with alterations in mental state
- 1.3.5 Headache with fever, neck stiffness and meningeal signs
- 1.3.6 Headache with focal neurological deficit if not previously documented as a migraine with aura
- 1.3.7 Substance abuse with amphetamine or cocaine
- 1.3.8 Patient is pregnant* or post-partum
- 1.3.9 Headache causing awakening from sleep or worsened by Valsalva manoeuvre;
- 1.3.10 Progressively worsening headache.

*Radiation risk and benefit for examination in pregnant women should be weighed based on individual case. During pregnancy, imaging modalities not associated with ionizing radiation (e.g. MRI) should be considered when appropriate.

1.4 Some specific conditions which are extracranial causes of headache render further investigation with imaging:

- 1.4.1 Middle or inner ear symptoms, including vertigo. If imaging is needed following specialist assessment, MRI is more sensitive, especially for acoustic neuromas.
- 1.4.2 For sinus disease if there has been failure of maximum medical treatment, and / or suspected complications, e.g. orbital cellulitis or suspicion of malignancy.
- 1.4.3 Congenital anomalies, benign and malignant neoplasms, trauma, vascular malformations, evaluation of palpable masses, planning and follow-up of radiotherapy.
- 1.4.4 Orbital lesions, including eye trauma in which there may be an associated facial fracture. US may be appropriate for intraocular lesions. CT scan may also be indicated for strong suspicion of an intraocular foreign body that has not been shown on X-ray.
- 1.4.5 Fractures of the temporal bone, skull, and face.
- 1.4.6 Evaluation of the skull base including primary and secondary bone lesions.

2 Plain radiograph

2.1 Plain skull radiography rarely contributes to the management of acute non-traumatic headache. Its main role is probably limited to headache of paranasal sinus origin, in which CT is still the preferred modality of examination.

3 CT

3.1 CT brain is sensitive to detect extravasated blood. Bony pathology is also best depicted by CT.

4 MRI

4.1 MRI is superior to CT in the assessment of most intracranial pathologies with the exception of acute haemorrhage and bony / calcific lesions.

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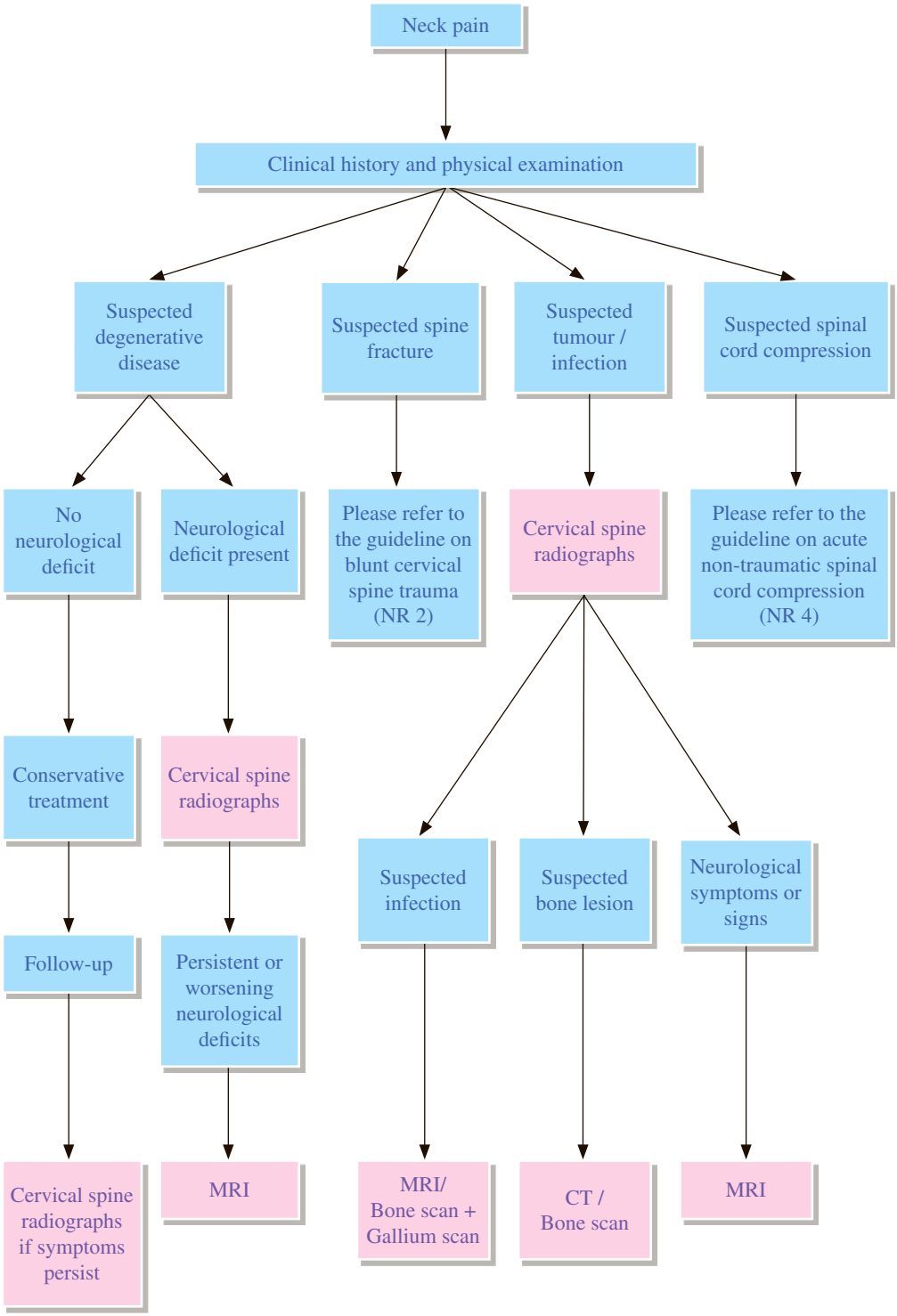
Neck pain
Clinical history and physical examination
Suspected degenerative disease
Suspected spine fracture
Suspected tumour / infection
Suspected spinal cord compression
No neurological deficit
Neurological deficit present
Please refer to the guideline on blunt cervical spine trauma (NR 2)
Cervical spine radiographs
Please refer to the guideline on acute non-traumatic spinal cord compression (NR 4)
Conservative treatment
Cervical spine radiographs
Suspected infection
Suspected bone lesion
Neurological symptoms or signs
Follow-up
Persistent or worsening neurological deficits
Cervical spine radiographs if symptoms persist
MRI
MRI/ Bone scan + Gallium scan
CT / Bone scan
MRI

REMARKS

1 Plain radiograph

1.1 Plain film abnormalities may not necessarily correlate with significant neurological lesion.

1.2 If CT is not available, open-mouth view may be needed to assess the C1/C2 region. Swimmer's view may be needed if the lower cervical levels are not well demonstrated on the lateral view.

1.3 Flexion and extension views are needed in patients with suspected ligamentous injury with normal initial radiographs.

1.4 Oblique radiographs are no longer recommended as part of the initial radiographic evaluation of the cervical spine in the setting of chronic neck pain.

2 Nuclear medicine

2.1 Combined gallium and bone scan studies have high sensitivity and specificity in diagnosing vertebral osteomyelitis and should be considered the imaging modality of choice when MRI is contraindicated.[1]

2.2 Use of single photon emission computed tomography (SPECT) imaging may be helpful in identifying the pain source e.g. facet disease.[2]

3 CT

3.1 CT myelography may be particularly advantageous in evaluating osseous lesion which contribute to canal or foraminal narrowing, and is a viable alternative to MRI for patients with suspected cord involvement, when MRI cannot be performed.[3]

3.2 Both CT and MRI can accurately diagnose tumors and inflammation, and they should be considered complementary studies.[4]

4 MRI

4.1 MRI gives excellent depiction of bone marrow signal, intervertebral discs, facet arthropathy and spinal stenosis, and may be considered the first line advanced imaging study in patients with chronic neck pain.[5]

4.2 Specific indications for MRI also include suspected malignancy or infection, whether neurological symptoms are present or not.[6]

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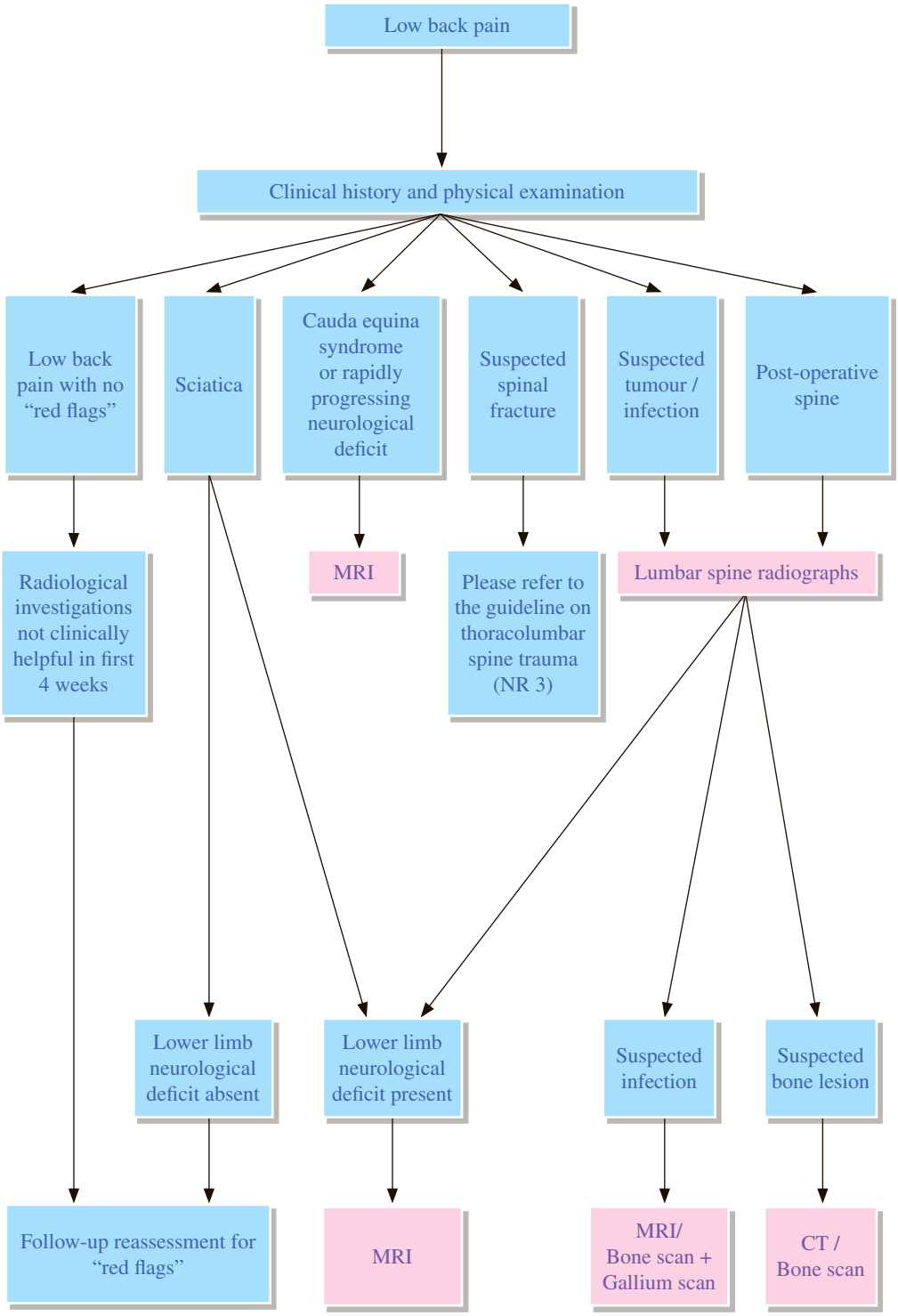
Low back pain
Clinical history and physical examination
Low back pain with no "red flags"
Sciatica
Cauda equina syndrome or rapidly progressing neurological deficit
Suspected spinal fracture
Suspected tumour / infection
Post-operative spine
Radiological investigations not clinically helpful in first 4 weeks
MRI
Please refer to the guideline on thoracolumbar spine trauma (NR 3)
Lumbar spine radiographs
Lower limb neurological deficit absent
Lower limb neurological deficit present
Suspected infection
Suspected bone lesion
Follow-up reassessment for "red flags"
MRI
MRI/ Bone scan + Gallium scan
CT / Bone scan

REMARKS

1 General

1.1 Uncomplicated acute low back pain and/or radiculopathy is a benign, self-limited condition that does not warrant any imaging studies.[2-6]

1.2 "Red flags" are indications of a more complicated status of back pain/radiculopathy in the following settings:[7,8]

- 1.2.1 Trauma, cumulative trauma
- 1.2.2 Insiduous onset of unexplained weight loss
- 1.2.3 Age > 50 years, especially women, and males with osteoporosis or compression fracture
- 1.2.4 Unexplained fever, history of urinary or other infection
- 1.2.5 Immunosuppression, diabetes mellitus
- 1.2.6 History of cancer
- 1.2.7 Intravenous drug abuse
- 1.2.8 Prolonged use of corticosteroids or osteoporosis
- 1.2.9 Age >70 years
- 1.2.10 Focal neurologic deficits with progressive or disabling symptoms, cauda equina syndrome
- 1.2.11 Duration > 6 weeks
- 1.2.12 Prior surgery

2 Plain radiographs

2.1 They are recommended if any of the "red-flags" are present.[9-10]

2.2 Lumbar spine radiographs may be sufficient for the initial evaluation of:

- 2.2.1 Recent significant trauma (any age)
- 2.2.2 Prolonged use of steroid
- 2.2.3 Osteoporosis
- 2.2.4 Age > 70 years

2.3 Oblique views may be useful for specific conditions like spondylolysis and facet joint disease.[11]

2.4 Radiographs have a role in evaluation of alignment, instability, and scoliosis and in postoperative evaluation of instrumentation and fusion.

3 Nuclear Medicine

3.1 Bone scan is moderately sensitive but nonspecific in diagnosing tumor, infection or occult vertebral fracture.[9,10] Specificity of diagnosis of skeletal infection is improved when correlating with gallium scintigraphy.

3.2 Bone scan is also useful in surveying the entire skeleton.

3.3 Single Photon Emission Computed Tomography (SPECT)/CT improves localization of active sites in bone scan.

4 MRI

4.1 Low back pain complicated with the red flags may justify early use of CT or MRI even if radiographs are negative.[9]

4.2 MRI is the imaging modality of choice in diagnosing disc herniation.[14-15] If MRI is not available or contraindicated, CT myelogram can be performed.

4.3 MRI with contrast is useful for suspected infection and neoplasia.

4.4 MRI with contrast allows distinction between disc and scar in post-operative patients.

5 CT

5.1 Provides superior bone detail but not as useful in depicting extradural soft tissue when compared with MRI.

5.2 Useful for depicting bone/structural lesions and alignment such as spondylolysis, pseudoarthrosis, fracture, scoliosis and stenosis and for post-surgical evaluation of bone graft integrity, surgical fusion and instrumentation.[16]

6 Myelography and CT myelography

6.1 Complementary to plain CT or MRI and occasionally more accurate in diagnosing disc herniation, but requires lumbar puncture and intrathecal contrast injection.[17-20]

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