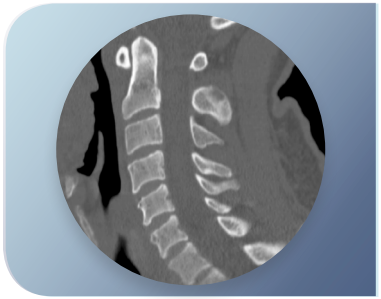


Intermountain Imaging Criteria:

Neck Pain

Through its Intermountain Imaging Criteria Project, Intermountain Healthcare has developed a suite of standardized care process models (CPMs) for the use of advanced imaging procedures in eight priority clinical areas. These evidence-based guidelines are intended to be widely implemented in order to improve patient safety, improve outcomes, and reduce unnecessary medical spending for the Medicare population and the U.S. health system overall.

Why Focus ON INTERMOUNTAIN IMAGING CRITERIA?

Advanced imaging procedures, including MRI, CT, PET, and nuclear medicine, facilitate rapid and accurate detection and/or diagnosis of disease. The volume of advanced imaging procedures prescribed to patients in the U.S. increased three- to four-fold from 1996–2010 as the technologies became widely available.[SMI] The inflating costs of advanced imaging outstripped that of any other medical service.[IGL, GAO] These inflating costs resulted in up to $20–30 billion in unnecessary advanced imaging spending each year.[NYDH]

- **High cost.** Although the spending growth in advanced imaging dropped off after the early 2000s, 2014 costs to Medicare Part B for advanced imaging exceeded $2.4 billion for common conditions alone.[LEV, CMS1]
- **Limited effectiveness.** Multiple studies suggest that up to a third of advanced imaging procedures fail to contribute to diagnosis or are clinically inappropriate.[NYDH]
- **Patient safety.** Advanced diagnostic imaging often exposes the patient to ionizing radiation and/or contrast media, posing additional medical risks that must be weighed against the potential benefits of the imaging procedure.
- **Overdiagnosis and overtreatment.** There is an unrecognized risk of overdiagnosis and subsequent overtreatment that carries associated risks (e.g., drug reactions or unnecessary surgical interventions) if advanced imaging is performed in patients with low pretest probability. The Intermountain Imaging Criteria approach seeks to avoid these risks.

GOALS AND MEASURES

Indicates an Intermountain measure

This CPM was developed by Intermountain clinical experts to outline appropriate use criteria (AUC) for advanced imaging for neck pain. These guidelines, together with those for other priority clinical areas, will improve the quality of care provided to patients by:

- Increasing adherence to evidence-based AUC for the use of advanced imaging
- Reducing imaging tests that do not conform to AUC or for which there are no guidelines
- Decreasing system-wide spending on unnecessary advanced imaging services
- Reducing the risk of harm from unwarranted radiation exposure
- Documenting the incidence of a significant positive on advanced imaging tests and aligning with downstream care

WHAT'S INSIDE?

OVERVIEW: INTERMOUNTAIN IMAGING CRITERIA AUC CONTENT 2

NECK PAIN (NP) CARE PATHWAY ALGORITHMS 5

- NP without complicating features 5
- NP + weakness (gradual onset of upper motor neuron symptoms and/or myelopathy) . . . 6
- NP + trauma (all settings) 7
- NP + suspected cervical artery dissection
  - Acute trauma 9
  - Not acute trauma 10
- NP + prior cervical neck surgery
  - No suspicion of hardware failure 11
  - With suspicion of hardware failure 12
- NP + suspected cancer 13
- NP + suspected infection
  - Spinal infection 14
  - Meningitis 15

POINT-OF-ORDER CHECKLISTS 16

RESOURCES 20

BIBLIOGRAPHY 21

REFERENCES 25

Intermountain Healthcare

OVERVIEW: INTERMOUNTAIN IMAGING CRITERIA AUC CONTENT

Intermountain Imaging Criteria appropriate use criteria (AUC) support clinicians in providing evidence-based care to the patients they serve. Although appropriate use of Intermountain Imaging Criteria fulfills compliance requirements under PAMA, patients only fully benefit from their use as they are deployed within the framework of a locally driven quality improvement program. To learn more about Intermountain's process for developing and maintaining AUC, visit: https://intermountainhealthcare.org/services/imaging-services/intermountain-imaging-criteria/.

The care process model approach

Designed as Care Process Models (CPMs), the Intermountain Imaging Criteria AUC content is a blueprint that logically guides the delivery of evidence-based care via an algorithmic visual presentation (see list at right and pages 5 through 15). Although these Intermountain Imaging Criteria CPMs specifically focus on the appropriate use of advanced imaging, they can rightly be viewed as portions of broader CPMs that guide not only diagnostic but therapeutic interventions for a specific disease or condition.

Ideally, Intermountain Imaging Criteria CPMs are engaged early in the patient encounter and guide the various considerations that lead to the ultimate decision regarding ordering of an imaging study. Point-of-order checklists are also included (beginning on page 18). These checklist-based guidelines are logically equivalent to the algorithms from which they are derived.

Knowing that local factors will invariably impact decisions about selecting the most appropriate exam, Intermountain Imaging Criteria CPMs specify the generally preferred exam but also provide alternative choices that may be appropriate in certain clinical settings.

Relative imaging cost and radiation risk rankings

To further aid providers, each algorithm includes a ranking of relative costs and radiation risk for each advanced imaging test recommended. The cost scale is derived using global non-facility relative value units (RVUs) published by the Centers for Medicare and Medicaid Services CMS as a surrogate for cost.[CMS2] The radiation risk is derived from data published in 2010 by the Health Physics Society.[ACR, HPS]

Evidentiary review and ranking

Intermountain used the following two conceptual frameworks for evidentiary review of relevant literature:

1. The 2011 revision of the *Oxford Centre for Evidence-Based Medicine (OCEBM) 2011 Levels of Evidence* standard. This standard includes categorical levelling grades relevant to diagnostic studies and rates individual sources of evidence (published papers or other research data) on a five-point scale.[OCE]
2. The extensively used Fryback and Thornbury conceptual framework, which uses six levels for assessing the efficacy of diagnostic imaging.[FRY]

Each algorithmic presentation provides both rankings for the decision node (pairing of AUC and recommended/alternative tests).

Using the algorithms and checklists

Under "Care Pathway" on page 3, there is an annotated algorithmic sample for a typical clinical scenario found in this CPM. Under "Point-of-Order Checklist" on page 4, there is an annotated sample of a typical point-of-order checklist for an imaging procedure recommended within the above sample algorithm.

Abbreviations used in this CPM

ALOC	=	altered level of consciousness
AS	=	ankylosing spondylitis
CPG	=	clinical practice guideline
CPM	=	care process model
CT	=	computed tomography
CTA	=	computed tomography angiography
DISH	=	diffuse idiopathic skeletal hyperostosis
DWI	=	diffusion weighted imaging
IV	=	intravenous
MRA	=	magnetic resonance angiogram
MRI	=	magnetic resonance imaging
NP	=	neck pain
PCP	=	primary care provider
PET	=	positron emission tomography
PM&R	=	pain management and rehabilitation

Intermountain® Healthcare

Care pathways

For each clinical scenario (e.g., neck pain and suspected cancer), there is an algorithmic presentation of the care pathway context for the imaging decisions made. This pathway contains not only the appropriate use criteria (AUC) and evidence-based advanced imaging recommendations, but also what constitutes significant positive imaging results and downstream care recommendations. Note the elements of this presentation below and key information provided in each test recommendation box as shown at right. There is also a legend at the bottom of each care pathway page.

The Arabic number in the green box indicates an evidence ranking derived from the OCEBM scale.[OCE] For this scale, the **lower** the number, the stronger the evidence ranking.

The Roman numeral in the orange box indicates an evidence ranking derived from the Fryback & Thornbury scale.[FRY] For this scale, the **higher** the number, the stronger the evidence ranking.

Cost rankings are indicated based on a range developed from the CMS Global Relative Value Units (RVUs) as follows:[CMS2]

$ = 0–5 RVU
$$ = 5–10 RVU
$$$ = 10–15 RVU
$$$$ = 15+ RVU

Radiation risk rankings use the scale developed by the American College of Radiology.[ACR] This rating framework offers the following six levels for adult effective dose range risk:

R0 = 0 mSv
R1 = < 0.1 mSv
R2 = 0.1–1 mSv
R3 = 1–10 mSv
R4 = 10–30 mSv
R5 = 30–100 mSv

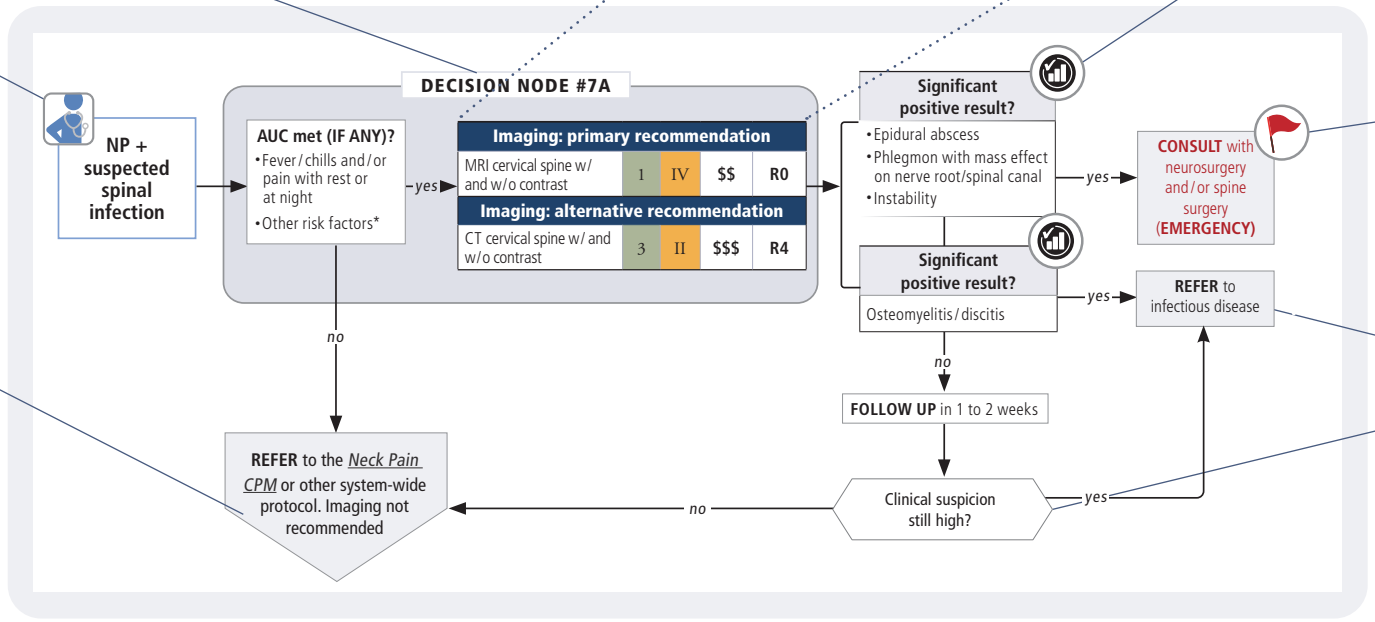
Imaging: primary recommendation				
MRI cervical spine w/ and w/o contrast	1	IV	$$	R0
Imaging: alternative recommendation				
CT cervical spine w/ and w/o contrast	3	II	$$$	R4

An alternate imaging recommendation has been included for when the primary recommendation is contraindicated or the alternative recommendation may be clinically appropriate.

The decision node box encompasses recommended advanced imaging based on the presence of evidence-based appropriate use criteria (AUC) or expert consensus (where evidence does not exist).

This symbol indicates an Intermountain internal measure. Intermountain measures incidence of significant positive results on advanced imaging tests.

This symbol indicates a common clinical scenario.



This red flag signifies an urgent or emergency situation (sometimes this red flag indicates a scenario that may require bypassing the AUC logic).

Underlining indicates a hyperlink to another document or to a page within the same document, as appropriate.

Downstream care recommendations are general guidelines and are subject to the discretion of individual healthcare providers and the providers' system protocols.

Point-of-order checklists

See abbreviations on page 2

For each advanced imaging test (e.g., MRI and CT), there is a checklist that compiles all of the appropriate use criteria from each clinical scenario (shown in the care pathways) for that test. Tables indicate if the test is a primary recommendation or alternate recommendation. These are presented in a checklist format for the provider to select the appropriate scenario AND the criteria that apply to the patient's situation.

Tables included on pages 16 through 19 indicate if the test is a primary recommendation or alternative recommendation.

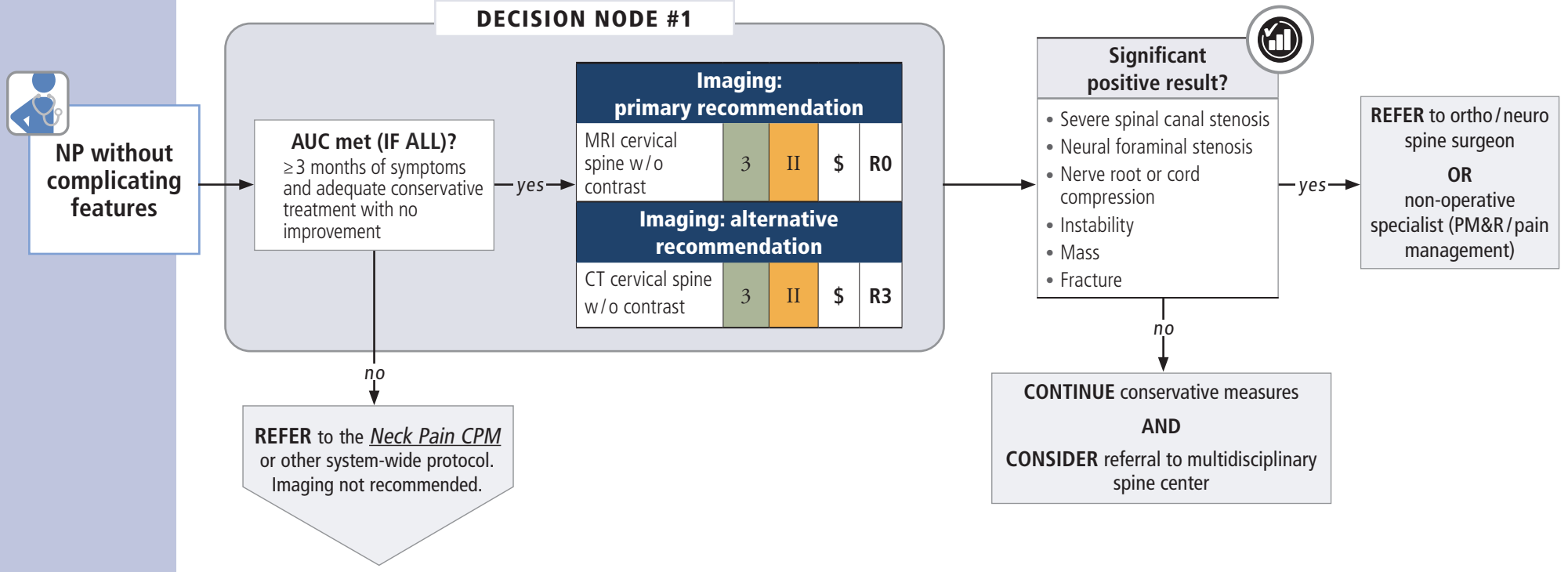
TABLE 2. MRI cervical spine WITH AND WITHOUT contrast appropriate use indications

(PRIMARY recommendation)

- ☐ **Neck pain without improvement + prior cervical spine surgery (NO suspicion of hardware failure) (IF ANY)**
  - ☐ Worsening neck pain
  - ☐ New or acute radiculopathy
  - ☐ Weakness
  - ☐ High suspicion of disc disease adjacent to hardware
- ☐ **Neck pain with suspected cancer (IF ANY)**
  - ☐ History of cancer
  - ☐ Multiple cancer risk factors
  - ☐ High suspicion of cancer
- ☐ **Neck pain with suspected spinal infection (IF ANY)**
  - ☐ Fever / chills and / or pain with rest or at night
  - ☐ Other risk factors **(ANY)**: immunocompromised patient, other site of infection, IV drug use

NECK PAIN (NP) CARE PATHWAY ALGORITHMS

See abbreviations on page 2



DECISION NODE #1 KEY EVIDENCE

American College of Radiology. ACR Appropriateness Criteria® Chronic Neck Pain. https://acsearch.acr.org/docs/69426/Narrative/. Accessed June 30, 2017.

Douglas-Akinwande AC, Rydberg J, Shah M V, et al. Accuracy of contrast-enhanced MDCT and MRI for identifying the severity and cause of neural foraminal stenosis in cervical radiculopathy: a prospective study. *Am J Roentgenol.* 2010;194(1):55-61.

Yousem DM, Atlas SW, Hackney DB. Cervical spine disk herniation: comparison of CT and 3DFT gradient echo MR scans. *J Comput Assist Tomogr.* 1992;16(3):345-351.

(For a full list of references for all decision nodes, see bibliography on pages 21 through 24)

LEGEND

Clinical Scenario | Urgent or Emergency Situation | 2 OCEBM Level of Evidence | II Fryback & Thornbury Level of Evidence | Intermountain Measure

R0 (0 mSv) **R3** (1–10 mSv) **R4** (10–30 mSv) See page 2–3 for explanation.
$** (0–5 RVUs) **$$** (5–10 RVUs) **$$$** (10–15 RVUs) **$$$$ (15+ RVUs)

See abbreviations on page 2

NP + neurologic deficit

DECISION NODE #2

AUC met? (If ANY):
- Hyperreflexia / Hoffman's sign
- New-onset Babinski or clonus
- New-onset gait or balance abnormalities
- Upper extremity weakness

yes →

EMERGENCY REFERRAL IF SUDDEN ONSET
Emergency spine consult if high suspicion

Imaging: primary recommendation				
MRI cervical, thoracic, and lumbar spine w/o contrast	3	II	$$$	R0
AND / OR				
MRI brain w/o contrast	4	II	$	R0
Imaging: alternative recommendation				
CT myelogram cervical and thoracic spine	2	III	$$$$	R4
AND / OR				
CT brain / head w/ and w/o contrast	4	II	$	R3

Significant positive result?
- Spine / cord compression
- Severe spinal canal stenosis
- Large disc herniation
- Brain mass

yes → **REFER to ortho / neuro spine surgeon (URGENT)**

Significant positive result?
- Cord signal change not associated with cord compression or spinal canal stenosis
- Findings consistent with MS
- Inflammation / infection

yes → **CONSULT** with neurology

no → **CONSIDER** consultation with neurology

no → **REFER** to the *Neck Pain* CPM or other system-wide protocol. Imaging not recommended.

DECISION NODE #2 KEY EVIDENCE

American College of Radiology. ACR Appropriateness Criteria® Chronic Neck Pain. https://acsearch.acr.org/docs/69426/Narrative/. Accessed June 30, 2017.

American College of Radiology. ACR Appropriateness Criteria® Focal Neurologic Deficit. https://acsearch.acr.org/docs/69477/Narrative/. Accessed August 31, 2017.

Naganawa T, Miyamoto K, Ogura H, Suzuki N, Shimizu K. Comparison of magnetic resonance imaging and computed tomogram-myelography for evaluation of cross sections of cervical spinal morphology. *Spine.* 2011;36(1):50-56.

(For a full list of references for all decision nodes, see bibliography on pages 21 through 24)

LEGEND

Clinical Scenario | Urgent or Emergency Situation | 2 OCEBM Level of Evidence | II Fryback & Thornbury Level of Evidence | Intermountain Measure

R0 (0 mSv) **R3** (1–10 mSv) **R4** (10–30 mSv) See page 2–3 for explanation.
$** (0–5 RVUs) **$$** (5–10 RVUs) **$$$** (10–15 RVUs) **$$$$ (15+ RVUs)

See abbreviations on page 2

NP + trauma (ALL settings)

DECISION NODE #3-1

AUC met?
Significant trauma (ED setting)

yes → **EMERGENCY trauma evaluation**

Imaging: primary recommendation

CT cervical spine w/o contrast	3	II	$	R3

Significant positive result?
- Fracture
- Dislocations
- Unstable alignment

yes → **REFER to ortho/neuro spine surgeon (URGENT)**

no

AUC met? (If ANY)
- Questionable findings or inadequate coverage on cervical spine radiograph
- Elevated clinical suspicion with negative radiograph
- Known spondyloarthropathy (AS or DISH)

yes → Imaging: primary recommendation

no → **REFER** to the *Neck Pain CPM* or other system-wide protocol. Imaging not recommended.

DECISION NODE #3-2

AUC met?*
- CT cervical spine completed

AND (ANY)
- Suspicion of occult fracture or ligamentous injury
- Known spondyloarthropathy (AS or DISH)
- Persistent neurologic deficit

yes →

Imaging: primary recommendation

MRI cervical spine w/o contrast	5	I	$	R0

Significant positive result (ANY)?
- Fractures
- Evidence of ligamentous injury
- Acute disc herniation/nerve compression
- Instability

yes → **REFER to ortho/neuro spine surgeon (URGENT)**

no → **MANAGE** in the ED per clinical judgement OR **FOLLOW UP** (non-surgical) in 1-2 weeks for all other settings

*** MRI not usually needed for trauma**

LEGEND

Clinical Scenario | Urgent or Emergency Situation | 2 OCEBM Level of Evidence | II Fryback & Thornbury Level of Evidence | Intermountain Measure

R0 (0 mSv) **R3** (1–10 mSv) **R4** (10–30 mSv) See page 2–3 for explanation.
$** (0–5 RVUs) **$$** (5–10 RVUs) **$$$** (10–15 RVUs) **$$$$ (15+ RVUs)

See abbreviations on page 2

DECISION NODE #3 KEY EVIDENCE

American College of Radiology. ACR Appropriateness Criteria® Chronic Neck Pain. https://acsearch.acr.org/docs/69426/Narrative/. Accessed June 30, 2017.

Bernard SA, Kransdorf MJ, Beaman FD, et al. ACR Appropriateness Criteria® chronic back pain suspected sacroiliitis-spondyloarthropathy. *J Am Coll Radiol.* 2017;14(5S):S62-S70.

(For a full list of references for all decision nodes, see bibliography on pages 21 through 24)

LEGEND

Clinical Scenario | Urgent or Emergency Situation | 2 OCEBM Level of Evidence | II Fryback & Thornbury Level of Evidence | Intermountain Measure

R0 (0 mSv) **R3** (1–10 mSv) **R4** (10–30 mSv) See page 2–3 for explanation.

$** (0–5 RVUs) **$$** (5–10 RVUs) **$$$** (10–15 RVUs) **$$$$ (15+ RVUs)

See abbreviations on page 2

NP + suspected cervical artery dissection (acute trauma)

DECISION NODE #4A-1

AUC met? (If ANY)
- Headache or facial pain
- Neurologic deficit(s) and/or stroke
- Horner syndrome: miosis, ptosis, and anhidrosis

yes

Consider EMERGENCY referral

Imaging: primary recommendation

CT brain/head w/o contrast	NA*	NA*	$	R3
AND				
CTA head and neck (include cervical spine CT reformatted from CTA data set)	3	II	$$$$	R3

Significant positive result?
Intracranial and/or cervical artery dissection

yes → **CONSULT** with neurology and/or interventional radiology

no

no → **REFER** to the *Concussion CPM* and/or *Neck Pain CPM* or other system-wide protocol. Imaging not recommended.

DECISION NODE #4A-2

AUC met (IF ANY)?
- Questionable CTA findings
- High clinical suspicion with negative CTA

yes

Imaging: primary recommendation

MRA head and neck	4	II	$$$$	R0

Significant positive result?
Intracranial and/or cervical artery dissection

yes → **CONSULT** with neurology and/or interventional radiology

no

no → **REFER** to the *Concussion CPM* and/or *Neck Pain CPM* or other system-wide protocol. Imaging not recommended.

*** Based on expert opinion in the absence of literature-based evidence**

DECISION NODE #4A KEY EVIDENCE

American College of Radiology. ACR Appropriateness Criteria® Chronic Neck Pain. https://acsearch.acr.org/docs/69426/Narrative/. Accessed June 30, 2017.

Vertinsky AT, Schwartz NE, Fischbein NJ, Rosenberg J, Albers GW, Zaharchuk G. Comparison of multidetector CT angiography and MR imaging of cervical artery dissection. AJNR *Am J Neuroradiol.* 2008;29(9):1753-1760.

(For a full list of references for all decision nodes, see bibliography on pages 21 through 24)

LEGEND

Clinical Scenario | Urgent or Emergency Situation | 2 OCEBM Level of Evidence | II Fryback & Thornbury Level of Evidence | Intermountain Measure

R0 (0 mSv) **R3** (1–10 mSv) **R4** (10–30 mSv) See page 2–3 for explanation.
$** (0–5 RVUs) **$$** (5–10 RVUs) **$$$** (10–15 RVUs) **$$$$ (15+ RVUs)

Intermountain® Healthcare

See abbreviations on page 2

NP + suspected cervical artery dissection (NOT acute trauma)

DECISION NODE #4B-1

AUC met (IF ANY)?
- Headache or facial pain
- Neurologic deficit(s) and/or stroke
- Horner syndrome: miosis, ptosis, and anhidrosis

yes → **Consider EMERGENCY referral**

Imaging: primary recommendation

CTA head and neck	3	II	$$$$	R3

Significant positive result?
Intracranial and/or cervical artery dissection

yes → **CONSULT** with neurology and/or interventional radiology

no

no

DECISION NODE #4B-2

AUC met (IF ANY)?
- Questionable CTA findings
- High clinical suspicion with negative CTA

yes →

Imaging: primary recommendation

MRA head and neck	4	II	$$$$	R0

Significant positive result?
Intracranial and/or cervical artery dissection

yes

no

no

REFER to the *Concussion CPM* and/or *Neck Pain CPM* or other system-wide protocol. Imaging not recommended.

DECISION NODE #4B KEY EVIDENCE

American College of Radiology. ACR Appropriateness Criteria® Chronic Neck Pain. https://acsearch.acr.org/docs/69426/Narrative/. Accessed June 30, 2017.

Vertinsky AT, Schwartz NE, Fischbein NJ, Rosenberg J, Albers GW, Zaharchuk G. Comparison of multidetector CT angiography and MR imaging of cervical artery dissection. AJNR *Am J Neuroradiol.* 2008;29(9):1753-1760.

(For a full list of references for all decision nodes, see bibliography on pages 21 through 24)

LEGEND

Clinical Scenario | Urgent or Emergency Situation | 2 OCEBM Level of Evidence | II Fryback & Thornbury Level of Evidence | Intermountain Measure

R0 (0 mSv) **R3** (1–10 mSv) **R4** (10–30 mSv) See page 2–3 for explanation.
$** (0–5 RVUs) **$$** (5–10 RVUs) **$$$** (10–15 RVUs) **$$$$ (15+ RVUs)

See abbreviations on page 2

NP without improvement + prior cervical spine surgery (NO suspicion of hardware failure)

DECISION NODE #5A

AUC met (IF ANY)?

- Worsening neck pain
- New or acute radiculopathy
- Weakness
- High suspicion of disc disease adjacent to hardware

yes

URGENT SPINE SURGERY REFERRAL
if radiculopathy with weakness / disabling

Imaging: primary recommendation				
MRI cervical spine w/ and w/o contrast	3	II	$$	R0
Imaging: alternative recommendation				
CT myelogram cervical spine	2	III	$$$$	R4

no

REFER to the *Neck Pain CPM* or other system-wide protocol. Imaging not recommended.

Significant positive result?

- Spinal stenosis
- Adjacent level disease
- Acute / new disc herniation
- Infection

yes

REFER to ortho / neuro spine surgeon

no

MANAGE with conservative measures per *Neck Pain CPM* (or other system-wide protocol) for 3 months

+

(If NOT improved) CONSIDER referral to ortho / neuro spine surgeon or multidisciplinary spine center

DECISION NODE #5A KEY EVIDENCE

American College of Radiology. ACR Appropriateness Criteria® Chronic Neck Pain. https://acsearch.acr.org/docs/69426/Narrative/. Accessed June 30, 2017.

(For a full list of references for all decision nodes, see bibliography on pages 21 through 24)

LEGEND

Clinical Scenario | Urgent or Emergency Situation | 2 OCEBM Level of Evidence | II Fryback & Thornbury Level of Evidence | Intermountain Measure

R0 (0 mSv) **R3** (1–10 mSv) **R4** (10–30 mSv) See page 2–3 for explanation.
$** (0–5 RVUs) **$$** (5–10 RVUs) **$$$** (10–15 RVUs) **$$$$ (15+ RVUs)

See abbreviations on page 2

NP + prior cervical spine surgery (WITH suspicion of hardware failure)

DECISION NODE #5B

AUC met (IF ANY)?

- Negative cervical spine radiograph with flex/ex lateral + AP/lateral
- Equivocal plain film findings

yes →

Imaging: primary recommendation

CT cervical spine w/o contrast	2	III	$	R3

Significant positive result?

- Hardware failure
- Halo around screws
- Evidence of incomplete or failed fusion
- New fractures

yes → **REFER** to ortho/neuro spine surgeon

no → **REFER** to ortho/neuro spine surgeon

no → **MANAGE** with conservative measures per *Neck Pain CPM* (or other system-wide protocol) for 3 months + (If NOT improved) **CONSIDER** referral to ortho/neuro spine surgeon **OR** multidisciplinary spine center

DECISION NODE #5B KEY EVIDENCE

American College of Radiology. ACR Appropriateness Criteria® Chronic Neck Pain. https://acsearch.acr.org/docs/69426/Narrative/. Accessed June 30, 2017.

(For a full list of references for all decision nodes, see bibliography on pages 21 through 24)

LEGEND

Clinical Scenario | Urgent or Emergency Situation | 2 OCEBM Level of Evidence | II Fryback & Thornbury Level of Evidence | Intermountain Measure

R0 (0 mSv) **R3** (1–10 mSv) **R4** (10–30 mSv) See page 2–3 for explanation.
$** (0–5 RVUs) **$$** (5–10 RVUs) **$$$** (10–15 RVUs) **$$$$ (15+ RVUs)

See abbreviations on page 2

NP + suspected cancer

DECISION NODE #6

AUC met (IF ANY)?
- History of cancer
- Multiple cancer risk factors
- High suspicion of cancer

yes

Imaging: primary recommendation				
MRI cervical spine w/ and w/o contrast	1	IV	$$	R0

Imaging: alternative recommendation				
CT cervical spine w/ and w/o contrast	3	II	$$$	R4

Significant positive result?
Evidence of neoplasm

yes → **CONSULT** with internal medicine, neurology, or oncology

Significant positive result?
- Mass effect on nerve root/spinal canal
- Instability

yes → **CONSULT** with neurosurgery and/or spine surgery

no → **FOLLOW UP** in 1–2 weeks

Clinical suspicion still high?

yes → **REFER** to oncology

no → **REFER** to the *Neck Pain CPM* or other system-wide protocol. Imaging not recommended.

no → **REFER** to the *Neck Pain CPM* or other system-wide protocol. Imaging not recommended.

DECISION NODE #6 KEY EVIDENCE

American College of Radiology. ACR Appropriateness Criteria® Chronic Neck Pain. https://acsearch.acr.org/docs/69426/Narrative/. Accessed June 30, 2017.

(For a full list of references for all decision nodes, see bibliography on pages 21 through 24)

LEGEND

Clinical Scenario | Urgent or Emergency Situation | 2 OCEBM Level of Evidence | II Fryback & Thornbury Level of Evidence | Intermountain Measure

R0 (0 mSv) **$** (0–5 RVUs) **R3** (1–10 mSv) **$$** (5–10 RVUs) **R4** (10–30 mSv) See page 2–3 for explanation. **$$$** (10–15 RVUs) **$$$$** (15+ RVUs)

NP + suspected spinal infection

DECISION NODE #7A

AUC met (IF ANY)?
- Fever / chills and / or pain with rest or at night
- Other risk factors*

yes

Imaging: primary recommendation				
MRI cervical spine w/ and w/o contrast	1	IV	$$	R0
Imaging: alternative recommendation				
CT cervical spine w/ and w/o contrast	3	II	$$$	R4

no

REFER to the *Neck Pain CPM* or other system-wide protocol. Imaging not recommended.

Significant positive result?
- Epidural abscess
- Phlegmon with mass effect on nerve root / spinal canal
- Instability

yes → **CONSULT** with neurosurgery and / or spine surgery (**EMERGENCY**)

Significant positive result?
- Osteomyelitis / discitis

yes → **REFER** to infectious disease

no

FOLLOW UP in 1 – 2 weeks

Clinical suspicion still high?

yes → **REFER** to infectious disease

no → **REFER** to the *Neck Pain CPM* or other system-wide protocol. Imaging not recommended.

See abbreviations on page 2

*** Other risk factors include, but are not limited to, immuno-compromised patient, other site of infection, and IV drug use.**

DECISION NODE #7A KEY EVIDENCE

American College of Radiology. ACR Appropriateness Criteria® Chronic Neck Pain. https://acsearch.acr.org/docs/69426/Narrative/. Accessed June 30, 2017.

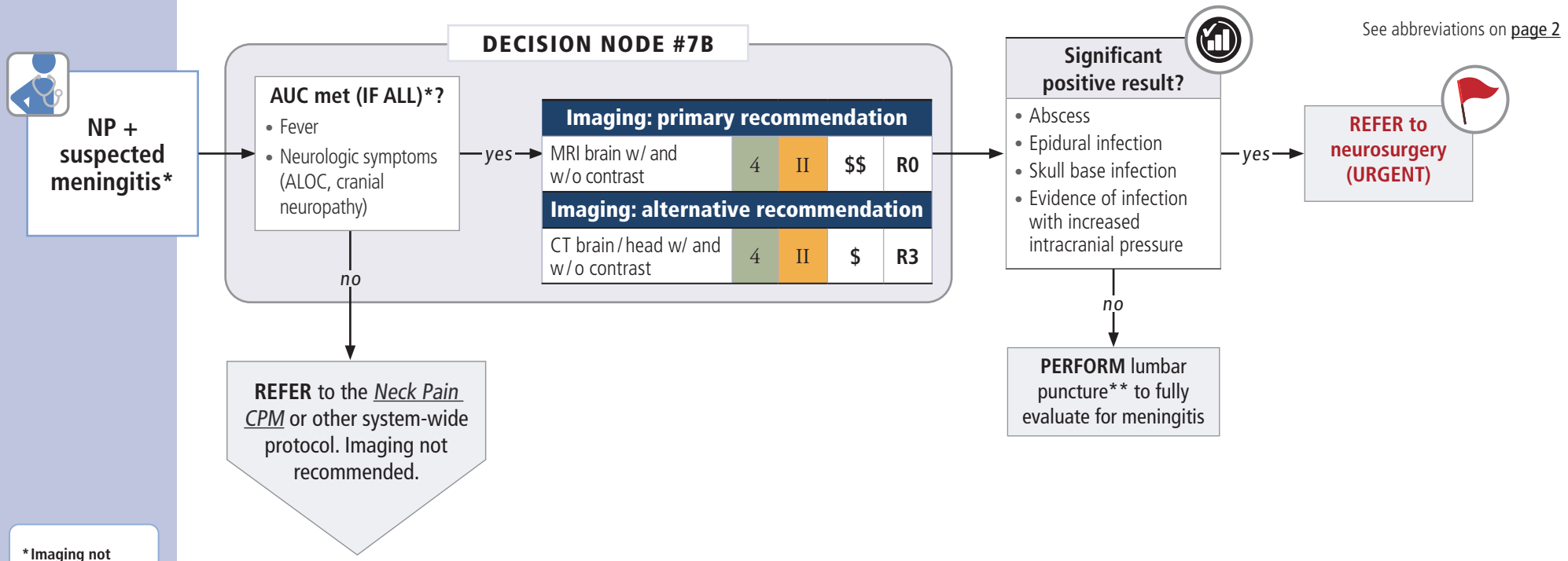
(For a full list of references for all decision nodes, see bibliography on pages 21 through 24)

LEGEND

Clinical Scenario | Urgent or Emergency Situation | 2 OCEBM Level of Evidence | II Fryback & Thornbury Level of Evidence | Intermountain Measure

R0 (0 mSv) **R3** (1 – 10 mSv) **R4** (10 – 30 mSv) See page 2 – 3 for explanation.
$** (0 – 5 RVUs) **$$** (5 – 10 RVUs) **$$$** (10 – 15 RVUs) **$$$$ (15+ RVUs)

Intermountain Healthcare



See abbreviations on page 2

***Imaging not generally indicated for meningitis without associated neurologic symptoms**

****CT head is not required prior to every lumbar puncture, but is recommended if have clinical suspicion of elevated intracranial pressure or altered mental status**

DECISION NODE #7B KEY EVIDENCE

Douglas AC, Wippold FJ, Broderick DF, et al. ACR Appropriateness Criteria® Headache. *J Am Coll Radiol.* 2014;11(7):657-667.

(For a full list of references for all decision nodes, see bibliography on pages 21 through 24)

LEGEND

Clinical Scenario | Urgent or Emergency Situation | 2 OCEBM Level of Evidence | II Fryback & Thornbury Level of Evidence | Intermountain Measure

R0 (0 mSv) **R3** (1–10 mSv) **R4** (10–30 mSv) See page 2–3 for explanation.
$** (0–5 RVUs) **$$** (5–10 RVUs) **$$$** (10–15 RVUs) **$$$$ (15+ RVUs)

POINT-OF-ORDER CHECKLISTS

See abbreviations on page 2

The provider must check BOTH:

1. The box next to the relevant clinical scenario
2. **EACH** AUC box that applies to the patient's situation

TABLE 1. MRI cervical spine WITHOUT CONTRAST appropriate use indications

(PRIMARY recommendation)

☐ **Neck pain without complicating features**

- ☐ ≥3 months of symptoms and adequate conservative treatment with no improvement

☐ **Neck pain with trauma (ALL settings)**

- ☐ Significant trauma (ED setting)

AND

- ☐ CT cervical spine w/out contrast completed

WITH ANY OF FOLLOWING

- ☐ Suspicion of occult fracture or ligamentous injury
- ☐ Known spondyloarthropathy (AS or DISH)
- ☐ Persistent neurologic deficit

OR

IF ANY

- ☐ Questionable findings or inadequate coverage on cervical spine radiograph
- ☐ Elevated clinical suspicion with negative radiograph
- ☐ Known spondyloarthropathy (AS or DISH)

AND

- ☐ CT cervical spine w/out contrast completed

WITH ANY OF FOLLOWING

- ☐ Suspicion of occult fracture or ligamentous injury
- ☐ Known spondyloarthropathy (AS or DISH)
- ☐ Persistent neurologic deficit

TABLE 2. MRI cervical spine WITH AND WITHOUT contrast appropriate use indications

(PRIMARY recommendation)

☐ **Neck pain without improvement + prior cervical spine surgery (NO suspicion of hardware failure) (IF ANY)**

- ☐ Worsening neck pain
- ☐ New or acute radiculopathy
- ☐ Weakness
- ☐ High suspicion of disc disease adjacent to hardware

☐ **Neck pain with suspected cancer (IF ANY)**

- ☐ History of cancer
- ☐ Multiple cancer risk factors
- ☐ High suspicion of cancer

☐ **Neck pain with suspected spinal infection (IF ANY)**

- ☐ Fever/chills and/or pain with rest or at night
- ☐ Other risk factors **(ANY)**: Immunocompromised patient, other site of infection, IV drug use

POINT-OF-ORDER CHECKLISTS, CONTINUED

See abbreviations on page 2

TABLE 3. MRI brain WITH AND WITHOUT contrast appropriate use indications

(PRIMARY recommendation)

☐ **Neck pain with suspected meningitis (IF ALL)**
- ☐ Fever
- ☐ Neurologic symptoms (ALOC, cranial neuropathy)

TABLE 4. MRI cervical, thoracic, and lumbar spine WITHOUT contrast appropriate use indications

(PRIMARY recommendation)

☐ **Neck pain with neurologic deficit (IF ANY)**
- ☐ Hyperreflexia / Hoffman's sign
- ☐ New-onset Babinski or clonus
- ☐ New-onset gait / balance abnormalities
- ☐ Upper extremity weakness

TABLE 5. MRI brain WITHOUT contrast appropriate use indications

(PRIMARY recommendation)

☐ **Neck pain with neurologic deficit (IF ANY)**
- ☐ Hyperreflexia / Hoffman's sign
- ☐ New-onset Babinski or clonus
- ☐ New-onset gait / balance abnormalities
- ☐ Upper extremity weakness

TABLE 6. MRA head and neck appropriate use indications

(PRIMARY recommendation)

☐ **Neck pain with suspected cervical artery dissection (acute trauma)**

IF ANY
- ☐ Headache or facial pain
- ☐ Neurologic deficit(s) and / or stroke
- ☐ Horner syndrome: miosis, ptosis, anhidrosis

AND
- ☐ Both CT brain / head w / out contrast AND CTA head / neck completed

WITH ANY OF FOLLOWING
- ☐ Questionable CTA findings
- ☐ High clinical suspicion with negative CTA

☐ **Neck pain with suspected cervical artery dissection (not acute trauma)**

IF ANY
- ☐ Headache or facial pain
- ☐ Neurologic deficit(s) and / or stroke
- ☐ Horner syndrome: miosis, ptosis, anhidrosis

AND
- ☐ CTA head / neck completed

WITH ANY OF FOLLOWING
- ☐ Questionable CTA findings
- ☐ High clinical suspicion with negative CTA

POINT-OF-ORDER CHECKLISTS, CONTINUED

See abbreviations on page 2

TABLE 7. CTA head and neck appropriate use indications

(PRIMARY recommendation)

- ☐ **Neck pain with suspected cervical artery dissection (acute trauma) (IF ANY)**
  - ☐ Headache or facial pain
  - ☐ Neurologic deficit(s) and / or stroke
  - ☐ Horner syndrome: miosis, ptosis, anhidrosis
- ☐ **Neck pain with suspected cervical artery dissection (not acute trauma) (IF ANY)**
  - ☐ Headache or facial pain
  - ☐ Neurologic deficit(s) and/or stroke
  - ☐ Horner syndrome: miosis, ptosis, anhidrosis

TABLE 8. CT brain / head WITHOUT contrast appropriate use indications

(PRIMARY recommendation)

- ☐ **Neck pain with suspected cervical artery dissection (acute trauma) (IF ANY)**
  - ☐ Headache or facial pain
  - ☐ Neurologic deficit(s) and / or stroke
  - ☐ Horner syndrome: miosis, ptosis, anhidrosis

TABLE 9. CT brain / head WITH AND WITHOUT contrast appropriate use indications

(ALTERNATIVE recommendation)

- ☐ **Neck pain with neurologic deficit (IF ANY)**
  - ☐ Hyperreflexia / Hoffman's sign
  - ☐ New-onset Babinski or clonus
  - ☐ New-onset gait / balance abnormalities
  - ☐ Upper extremity weakness
- ☐ **Neck pain with suspected meningitis (IF All)**
  - ☐ Fever
  - ☐ Neurologic symptoms (ALOC, cranial neuropathy)

POINT-OF-ORDER CHECKLISTS, CONTINUED

See abbreviations on page 2

TABLE 10. CT cervical spine WITHOUT contrast appropriate use indications

(PRIMARY recommendation)

- ☐ **Neck pain with trauma (ALL settings)**
  - ☐ Significant trauma (ED setting)

  OR (IF ANY)
  - ☐ Questionable findings or inadequate coverage on cervical spine radiograph
  - ☐ Elevated clinical suspicion with negative radiograph
  - ☐ Known spondyloarthropathy (AS or DISH)
- ☐ **Neck pain with prior cervical spine surgery (with suspicion of hardware failure) (IF ANY)**
  - ☐ Negative cervical spine radiograph with flex/ex lateral + AP/lateral
  - ☐ Equivocal plain film findings

(ALTERNATIVE recommendation)

- ☐ **Neck pain without complicating features**
  - ☐ ≥3 months of symptoms and adequate conservative treatment with no improvement

TABLE 11. CT cervical spine WITH AND WITHOUT contrast appropriate use indications

(ALTERNATIVE recommendation)

- ☐ **Neck pain with suspected cancer (IF ANY)**
  - ☐ History of cancer
  - ☐ Multiple cancer risk factors
  - ☐ High suspicion of cancer
- ☐ **Neck pain with suspected spinal infection (IF ANY)**
  - ☐ Fever/chills and/or pain with rest or at night
  - ☐ Other risk factors **(ANY)**: immunocompromised patient, other site of infection, IV drug use

TABLE 12. CT myelogram cervical spine appropriate use indications

(ALTERNATIVE recommendation)

- ☐ **Neck pain without improvement + prior cervical spine surgery (NO suspicion of hardware failure) (IF ANY)**
  - ☐ Worsening neck pain
  - ☐ New or acute radiculopathy
  - ☐ Weakness
  - ☐ High suspicion of disc disease adjacent to hardware

TABLE 13. CT myelogram cervical and thoracic spine appropriate use indications

(ALTERNATIVE recommendation)

- ☐ **Neck pain with neurologic deficit (IF ANY)**
  - ☐ Hyperreflexia/Hoffman's sign
  - ☐ New-onset Babinski or clonus
  - ☐ New-onset gait/balance abnormalities
  - ☐ Upper extremity weakness

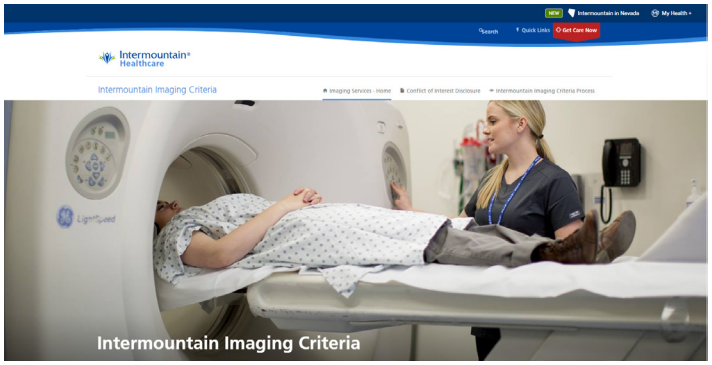
RESOURCES

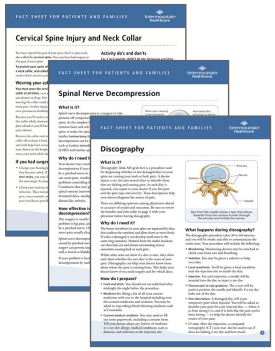
Intermountain provides educational materials designed to support providers in their efforts to care for, educate, and engage patients and their families.

Intermountain's patient education materials complement and reinforce clinical team interventions by providing a means for patients to reflect and learn in another mode and at their own pace.

Intermountain's Care Process Models (CPMs) outline evidence-based guidelines for patient care. In addition to the suite of Intermountain Imaging Criteria CPMs, Intermountain provides topical CPMs that have been developed by expert clinical teams. They can be accessed by navigating to intermountainphysician.org and selecting **Care Process Models** in the **Tools and Resources** drop down menu.

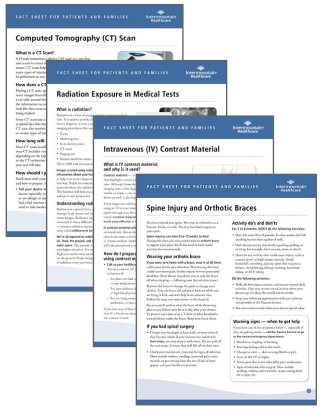
To access Intermountain Imaging Criteria CPMs and supporting materials, visit: https://intermountainhealthcare.org/services/imaging-services/intermountain-imaging-criteria/.





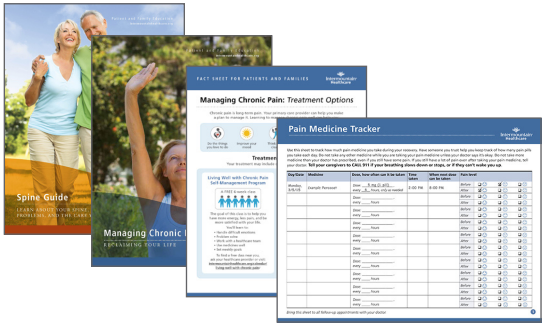
Fact sheets:

- *Cervical Spine Injury and Neck Collar* (English) / (Spanish)
- *Spinal Nerve Decompression* (English) / (Spanish)
- *Discography* (English) / (Spanish)



Fact sheets:

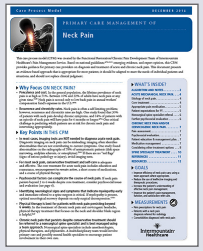
- *CT Scan* (English) / (Spanish)
- *Radiation Exposure in Medical Tests* (English) / (Spanish)
- *Intravenous (IV) Contrast Material* (English) / (Spanish)
- *Spine Injury and Orthotic Braces* (English) / (Spanish)



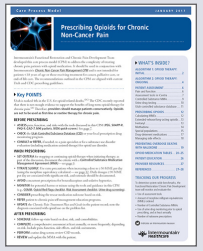
Patient education:

- *Spine Guide* (English)
- *Managing Chronic Pain* (English)
- *Managing Chronic Pain: Treatment Options* (English) / (Spanish)
- *Pain Medicine Tracker* (English) / (Spanish)

Related Care Process Models (CPMs):



Neck Pain CPM



Prescribing Opioids for Chronic Pain CPM

Imaging Radiation Exposure CPM

BIBLIOGRAPHY

NODE #1

1. American College of Radiology. ACR Appropriateness Criteria® Chronic Neck Pain. https://acsearch.acr.org/docs/69426/Narrative/. Accessed June 30, 2017.
2. Bono CM, Ghiselli G, Gilbert TJ, et al; North American Spine Society. An evidence-based clinical guideline for the diagnosis and treatment of cervical radiculopathy from degenerative disorders. *Spine J.* 2011;11(1):64-72.
3. Boutin RD, Steinbach LS, Finnesey K. MR imaging of degenerative diseases in the cervical spine. *Magn Reson Imaging Clin N Am.* 2000;8(3):471-490.
4. Douglas-Akinwande AC, Rydberg J, Shah M V. et al. Accuracy of contrast-enhanced MDCT and MRI for identifying the severity and cause of neural foraminal stenosis in cervical radiculopathy: A prospective Study. *Am J Roentgenol.* 2010;194(1):55-61.
5. Laker SR, Concannon LG. Radiologic evaluation of the neck: A review of radiography, ultrasonography, computed tomography, magnetic resonance imaging, and other imaging modalities for neck pain. *Phys Med Rehabil Clin N Am.* 2011;22(3):411-428, vii-viii.
6. Larsson EM, Holtås S, Cronqvist S, Brandt L. Comparison of myelography, CT myelography and magnetic resonance imaging in cervical spondylosis and disk herniation. Pre- and postoperative findings. *Acta Radiol.* 1989;30(3):233-239.
7. Pompan DC. Appropriate use of MRI for evaluating common musculoskeletal conditions. *Am Fam Physician.* 2011;83(8):883-884.
8. Van de Kelft E, van Vyve M. Diagnostic imaging algorithm for cervical soft disc herniation. *J Neurol Neurosurg Psychiatry.* 1994;57(6):724-728.
9. Yousem DM, Atlas SW, Hackney DB. Cervical spine disk herniation: Comparison of CT and 3DFT gradient echo MR scans. *J Comput Assist Tomogr. 1992;*16(3):345-351.

NODE #2

1. American College of Radiology. ACR Appropriateness Criteria® Chronic Neck Pain. https://acsearch.acr.org/docs/69426/Narrative/. Accessed June 30, 2017.
2. American College of Radiology. ACR Appropriateness Criteria® Focal Neurologic Deficit. https://acsearch.acr.org/docs/69477/Narrative/. Accessed August 31, 2017.
3. Bono CM, Ghiselli G, Gilbert TJ, et al; North American Spine Society. An evidence-based clinical guideline for the diagnosis and treatment of cervical radiculopathy from degenerative disorders. *Spine J.* 2011;11(1):64-72.
4. Boutin RD, Steinbach LS, Finnesey K. MR Imaging of degenerative diseases in the cervical spine. *Magn Reson Imaging Clin N Am.* 2000;8(3):471-490.
5. Di Chiro G, Schellinger D. Computed tomography of spinal cord after lumbar intrathecal introduction of metrizamide (computer-assisted myelography). *Radiology.* 1976;120(1):101-104.
6. Douglas-Akinwande AC, Rydberg J, Shah M V., et al. Accuracy of contrast-enhanced MDCT and MRI for identifying the severity and cause of neural foraminal stenosis in cervical radiculopathy: A prospective Study. *Am J Roentgenol.* 2010;194(1):55-61.
7. Laker SR, Concannon LG. Radiologic evaluation of the neck: A review of radiography, ultrasonography, computed tomography, magnetic resonance imaging, and other imaging modalities for neck pain. *Phys Med Rehabil Clin N Am.* 2011;22(3):411-428, vii-viii.
8. Larsson EM, Holtås S, Cronqvist S, Brandt L. Comparison of myelography, CT myelography and magnetic resonance imaging in cervical spondylosis and disk herniation. Pre- and postoperative findings. *Acta Radiol.* 1989;30(3):233-239.
9. Morita M, Miyauchi A, Okuda S, Oda T, Iwasaki M. Comparison between MRI and myelography in lumbar spinal canal stenosis for the decision of levels of decompression surgery. *J Spinal Disord Tech.* 2011;24(1):31-36.
10. Naganawa T, Miyamoto K, Ogura H, Suzuki N, Shimizu K. Comparison of magnetic resonance imaging and computed tomogram-myelography for evaluation of cross sections of cervical spinal morphology. *Spine.* 2011;36(1):50-56.
11. Pompan DC. Appropriate use of MRI for evaluating common musculoskeletal conditions. *Am Fam Physician.* 2011;83(8):883-884.
12. Sandow BA, Donnal JF. Myelography complications and current practice patterns. AJNR *Am J Roentgenol.* 2005;185(3):768-771.
13. Sicard JA, Forestier J. Méthode radiologique d'exploration de la cavité épidurale par le lipiodol. *Revista de Neurología.* 1921; 28:1264–1266.
14. Van de Kelft E, van Vyve M. Diagnostic imaging algorithm for cervical soft disc herniation. *J Neurol Neurosurg Psychiatry.* 1994;57(6):724-728.
15. Whitcomb BB, Wyatt GM. Technique of Pantopaque Myelography. *J Neurosurg.* 1946;3:95-99.
16. Wippold FJ, Brunberg JA, Cornelius RS, et al. American College of Radiology Appropriateness Criteria®: Focal Neurologic Deficit. *AJNR.* 2008 Nov, 29 (10) 1998-2000.
17. Yousem DM, Atlas SW, Hackney DB. Cervical spine disk herniation: Comparison of CT and 3DFT gradient echo MR scans. *J Comput Assist Tomogr.* 1992;16(3):345-351.

NODE #3

1. American College of Radiology. ACR Appropriateness Criteria® Chronic Neck Pain. https://acsearch.acr.org/docs/69426/Narrative/. Accessed June 30, 2017.
2. Bernard SA, Kransdorf MJ, Beaman FD, et al. ACR Appropriateness Criteria® chronic back pain suspected sacroiliitis-spondyloarthropathy. *J Am Coll Radiol.* 2017;14(5S):S62-S70.
3. Daffner RH, Hackney DB. ACR Appropriateness Criteria® on suspected spine trauma. *J Am Coll Radiol.* 2007 Nov;4(11):762-775.

BIBLIOGRAPHY, CONTINUED

4. Hanson JA, Blackmore CC, Mann FA, Wilson AJ. Cervical spine injury: A clinical decision rule to identify high-risk patients for helical CT screening. *AJR Am J Roentgenol.* 2000;174(3):713-717.
5. Mirvis SE, Diaconis JN, Chirico PA, Reiner BI, Joslyn JN, Militello P. Protocol-driven radiologic evaluation of suspected cervical spine injury: Efficacy study. *Radiology.* 1989;170(3 Pt 1):831-834.
6. Munera F, Rivas LA, Nuñez DB Jr, Quencer RM. Imaging evaluation of adult spinal injuries: Emphasis on multidetector CT in cervical spine trauma. *Radiology.* 2012;263(3):645-660.
7. Nuñez DB Jr, Quencer RM. The role of helical CT in the assessment of cervical spine injuries. *AJR Am J Roentgenol.* 1998;171(4):951-957.
8. Rao SK, Wasyliw C, Nuñez DB Jr. Spectrum of imaging findings in hyperextension injuries of the neck. *Radiographics.* 2005;25(5):1239-1254.
9. Wang YF, Teng MM, Chang CY, Wu HT, Wang ST. Imaging manifestations of spinal fractures in ankylosing spondylitis. *AJNR Am J Neuroradiol.* 2005;26(8):2067-2076.

NODE #4A and #4B

10. American College of Radiology. ACR Appropriateness Criteria® Chronic Neck Pain. https://acsearch. acr.org/docs/69426/Narrative/. Accessed June 30, 2017.
11. Biffl WL, Egglin T, Benedetto B, Gibbs F, Cioffi WG. Sixteen-slice computed tomographic angiography is a reliable noninvasive screening test for clinically significant blunt cerebrovascular injuries. *J Trauma.* 2006;60(4):745-751.
12. Biffl WL, Ray CE, Moore EE, Mestek M, Johnson JL, Burch JM. Noninvasive diagnosis of blunt cerebrovascular injuries: a preliminary report. *J Trauma.* 2002;53(5):850-856.
13. Djouhri H, Guillon B, Brunereau L, et al. MR angiography for the long-term follow-up of dissecting aneurysms of the extracranial internal carotid artery. AJR *Am J Roentgenol.* 2000;174(4):1137-1140.
14. Eastman AL, Chason DP, Perez CL, McAnulty AL, Minei JP. Computed tomographic angiography for the diagnosis of blunt cervical vascular injury: Is it ready for primetime? *J Trauma.* 2006;60(5):925-929.
15. Houser OW, Mokri B, Sundt TM, Baker HL, Reese DF. Spontaneous cervical cephalic arterial dissection and its residuum: Angiographic spectrum. *AJNR Am J Neuroradiol. 1984;*5(1):27-34.
16. Kasner SE, Hankins LL, Bratina P, Morgenstern LB. Magnetic resonance angiography demonstrates vascular healing of carotid and vertebral artery dissections. *Stroke.* 1997;28(10):1993-1997.
17. Kirsch E, Kaim A, Engelter S, et al. MR angiography in internal carotid artery dissection: Improvement of diagnosis by selective demonstration of the intramural haematoma. *Neuroradiology.* 1998;40(11):704-709.
18. Leclerc X, Lucas C, Godefroy O, et al. Preliminary experience using contrast-enhanced MR angiography to assess vertebral artery structure for the follow-up of suspected dissection. *AJNR Am J Neuroradiol.* 1999;20(8):1482-1490.
19. Malhotra AK, Camacho M, Ivatury RR, et al. Computed tomographic angiography for the diagnosis of blunt carotid/vertebral artery injury: A note of caution. *Ann Surg.* 2007;246(4):632-642.
20. Miller PR, Fabian TC, Croce MA, et al. Prospective screening for blunt cerebrovascular injuries: Analysis of diagnostic modalities and outcomes. *Ann Surg.* 2002;236(3):386-393.
21. Schievink WI. Spontaneous dissection of the carotid and vertebral arteries. *N Engl J Med.* 2001;344(12):898-906.
22. Shetty VS, Reis MN, Aulino JM, et al. ACR Appropriateness Criteria® Head Trauma. *J Am Coll Radiol.* 2016;13(6):668-679.
23. Vertinsky AT, Schwartz NE, Fischbein NJ, Rosenberg J, Albers GW, Zaharchuk G. Comparison of multidetector CT angiography and MR imaging of cervical artery dissection. AJNR *Am J Neuroradiol.* 2008;29(9):1753-1760.

NODE #5A

1. American College of Radiology. ACR Appropriateness Criteria® Chronic Neck Pain. https://acsearch.acr.org/docs/69426/Narrative/. Accessed June 30, 2017.
2. Ghiselli G, Wharton N, Hipp JA, Wong DA, Jatana S. Prospective analysis of imaging prediction of pseudarthrosis after anterior cervical discectomy and fusion: Computed tomography versus flexion-extension motion analysis with intraoperative correlation. *Spine.* 2011;36(6):463-468.
3. Hong JT, Sung JH, Son BC, Lee SW, Park CK. Significance of laminar screw fixation in the subaxial cervical spine. *Spine (Phila Pa 1976).* 2008;33(16):1739-1743.
4. Hwang IC, Kang DH, Han JW, Park IS, Lee CH, Park SY. Clinical experiences and usefulness of cervical posterior stabilization with polyaxial screw-rod system. *J Korean Neurosurg Soc.* 2007;42(4):311-316.
5. Park JY, Kim KH, Kuh SU, Chin DK, Kim KS, Cho YE. What are the associative factors of adjacent segment degeneration after anterior cervical spine surgery? Comparative study between anterior cervical fusion and arthroplasty with 5-year follow-up MRI and CT. *Eur Spine J.* 2013;22(5):1078-1089.
6. Rajakumar DV, Hari A, Krishna M, Konar S, Sharma A. Adjacent-level arthroplasty following cervical fusion. *Neurosurg Focus.* 2017 Feb;42(2): E5.
7. Yi S, Lee DY, Ahn PG, Kim KN, Yoon DH, Shin HC. Radiologically documented adjacent-segment degeneration after cervical arthroplasty: Characteristics and review of cases. *Surg Neurol.* 2009;72(4):325-329.

BIBLIOGRAPHY, CONTINUED

NODE #5B

1. American College of Radiology. ACR Appropriateness Criteria® Chronic Neck Pain. https://acsearch.acr.org/docs/69426/Narrative/. Accessed June 30, 2017.
2. Buckwalter KA, Rydberg J, Kopecky KK, Crow K, Yang EL. Musculoskeletal imaging with multislice CT. *AJR Am J Roentgenol.* 2001;176(4):979-986.
3. Calisir C, Fayad LM, Carrino JA, Fishman EK.Recognition, assessment, and treatment of non-union after surgical fixation of fractures: Emphasis on 3D CT. *Jpn J Radiol.* 2012 Jan;30(1):1-9.
4. Hwang IC, Kang DH, Han JW, Park IS, Lee CH, Park SY. Clinical experiences and usefulness of cervical posterior stabilization with polyaxial screw-rod system. *J Korean Neurosurg Soc.* 2007;42(4):311-316.
5. Kobayashi Y, Shinozaki Y, Takahashi Y, Takaishi H, Ogawa J. Risk factors for intervertebral instability assessed by temporal evaluation of the radiographs and reconstructed computed tomography images after L5-S1 single-level transforaminal interbody fusion: A retrospective study. *J Clin Neurosci.* 2017;35:92-96.
6. Ohashi K, El-Khoury GY, Bennett DL, Restrepo JM, Berbaum KS. Orthopedic hardware complications diagnosed with multi-detector row CT. *Radiology.* 2005;237(2):570-577.
7. Ryu WH, Kowalczyk I, Duggal N. Long-term kinematic analysis of cervical spine after single-level implantation of Bryan cervical disc prosthesis. *Spine J.* 2013;13(6):628-634.
8. Willson MC, Ross JS. Postoperative spine complications. *Neuroimaging Clin N Am.* 2014;24(2):305-326.

NODE #6

1. Abdel-Wanis ME, Solyman MT, Hasan NM. Sensitivity, specificity and accuracy of magnetic resonance imaging for differentiating vertebral compression fractures caused by malignancy, osteoporosis, and infections. *J Orthop Surg (Hong Kong).* 2011;19(2):145-150.
2. Algra PR, Bloem JL, Tissing H, Falke TH, Arndt JW, Verboom LJ. Detection of vertebral metastases: Comparison between MR imaging and bone scintigraphy. *Radiographics.* 1991;11(2):219-232.
3. American College of Radiology. ACR Appropriateness Criteria® Chronic Neck Pain. https://acsearch.acr.org/docs/69426/Narrative/. Accessed June 30, 2017.
4. Colletti PM, Dang HT, Deseran MW, Kerr RM, Boswell WD, Ralls PW. Spinal MR imaging in suspected metastases: Correlation with skeletal scintigraphy. *Magn Reson Imaging.* 1991;9(3):349-355.
5. Gold RH, Hawkins RA, Katz RD. Bacterial osteomyelitis: Findings on plain radiography, CT, MR, and scintigraphy. *AJR Am J Roentgenol.* 1991;157(2):365-370.
6. Guillevin R, Vallee JN, Lafitte F, Menuel C, Duverneuil NM, Chiras J. Spine metastasis imaging: Review of the literature. *J Neuroradiol.* 2007;34(5):311-321.
7. Termaat MF, Raijmakers PG, Scholten HJ, Bakker FC, Patka P, Haarman HJ. The accuracy of diagnostic imaging for the assessment of chronic osteomyelitis: a systematic review and meta-analysis. *J Bone Joint Surg Am.* 2005;87(11):2464-2471.
8. Thawait SK, Marcus MA, Morrison WB, Klufas RA, Eng J, Carrino JA. Research synthesis: what is the diagnostic performance of magnetic resonance imaging to discriminate benign from malignant vertebral compression fractures? Systematic review and meta-analysis. *Spine. (Phila Pa 1976).* 2012;37(12):E736-E744.

NODE #7A

9. Abdel-Wanis ME, Solyman MT, Hasan NM. Sensitivity, specificity and accuracy of magnetic resonance imaging for differentiating vertebral compression fractures caused by malignancy, osteoporosis, and infections. *J Orthop Surg (Hong Kong).* 2011;19(2):145-150.
10. Algra PR, Bloem JL, Tissing H, Falke TH, Arndt JW, Verboom LJ. Detection of vertebral metastases: Comparison between MR imaging and bone scintigraphy. *Radiographics.* 1991;11(2):219-232.
11. American College of Radiology. ACR Appropriateness Criteria® Chronic Neck Pain. https://acsearch.acr.org/docs/69426/Narrative/. Accessed June 30, 2017.
12. Colletti PM, Dang HT, Deseran MW, Kerr RM, Boswell WD, Ralls PW. Spinal MR imaging in suspected metastases: Correlation with skeletal scintigraphy. *Magn Reson Imaging.* 1991;9(3):349-355.
13. Gold RH, Hawkins RA, Katz RD. Bacterial osteomyelitis: Findings on plain radiography, CT, MR, and scintigraphy. *AJR Am J Roentgenol.* 1991;157(2):365-370.
14. Guillevin R, Vallee JN, Lafitte F, Menuel C, Duverneuil NM, Chiras J. Spine metastasis imaging: Review of the literature. *J Neuroradiol.* 2007;34(5):311-321.
15. Termaat MF, Raijmakers PG, Scholten HJ, Bakker FC, Patka P, Haarman HJ. The accuracy of diagnostic imaging for the assessment of chronic osteomyelitis: A systematic review and meta-analysis. *J Bone Joint Surg Am.* 2005;87(11):2464-2471.
16. Thawait SK, Marcus MA, Morrison WB, Klufas RA, Eng J, Carrino JA. Research synthesis: What is the diagnostic performance of magnetic resonance imaging to discriminate benign from malignant vertebral compression fractures? Systematic review and meta-analysis. *Spine. (Phila Pa 1976).* 2012;37(12):E736-E744.

BIBLIOGRAPHY, CONTINUED

NODE #7B

1. Castillo M. Imaging of meningitis. *Semin Roentgenol.* 2004;39(4):458-464.
2. Douglas AC, Wippold FJ 2nd, Broderick DF, et al. ACR Appropriateness Criteria® Headache. *J Am Coll Radiol.* 2014;11(7):657-667.
3. Hasbun R, Abrahams J, Jekel J, Quagliarello VJ. Computed tomography of the head before lumbar puncture in adults with suspected meningitis. *N Engl J Med.* 2001;345(24):1727-1733.
4. Kastrup O, Wanke I, Maschke M. Neuroimaging of infections. *NeuroRX.* 2005;2(2):324-332.
5. Malani AN, Vandenberg DM, Singal B, et al. Magnetic resonance imaging screening to identify spinal and paraspinal infections associated with injections of contaminated methylprednisolone acetate. *JAMA.* 2013;309(23):2465-2472.
6. Maschke M, Kastrup O, Forsting M, Diener HC. Update on neuroimaging in infectious central nervous system disease. *Curr Opin Neurol.* 2004;17(4):475-480.
7. Tunkel AR, Hartman BJ, Kaplan SL, et al. Practice guidelines for the management of bacterial meningitis. *Clin Infect Dis.* 2004;39(9):1267-1284.

REFERENCES (from pages 1 through 3)

ACR American College of Radiology. *ACR Appropriateness Criteria® Radiation Dose Assessment Introduction.* https://www.acr.org/-/media/ACR/Files/Appropriateness-Criteria/RadiationDoseAssessmentIntro.pdf. Accessed July 26, 2017.

CMS1 Centers for Medicare & Medicaid Services (CMS). Medicare claims data set. https://www.cms.gov/Medicare/Quality-Initiatives-Patient-Assessment-Instruments/Appropriate-Use-Criteria-Program/data.html. Published 2016. Accessed June 27, 2017.

CMS2 Centers for Medicare & Medicaid Services (CMS). Physician fee schedule. https://www.cms.gov/Medicare/Medicare-Fee-for-Service-Payment/PhysicianFeeSched/. Published July 17, 2017. Accessed August 8, 2017.

FRY Fryback DG, Thornbury JR. The efficacy of diagnostic imaging. *Med Decis Making* 1991;11(2):88-94.

GAO United States Government Accountability Office (GAO). Medicare Part B imaging services: Rapid spending growth and shift to physician offices indicate need for CMS to consider additional management practices. 2008;(GAO-08-452). http://www.gao.gov/products/GAO-08-452. Accessed June 13, 2017.

HPS Health Physics Society. *Radiation Exposure from Medical Exams and Procedures: Fact Sheet.* https://hps.org/documents/Medical_Exposures_Fact_Sheet.pdf. Accessed July 31, 2017.

IGL Iglehart JK. Health insurers and medical-imaging policy—A work in progress. *N Engl J Med.* 2009;360(10):1030-1037.

LEV Levin DC, Parker L, Palit CD, Rao VM. After nearly a decade of rapid growth, use and complexity of imaging declined, 2008-14. *Health Aff* (Millwood). 2017;36(4):663-670.

NYDH New York State Department of Health (NYDH). Advanced diagnostic imaging: Background on use, patient safety, costs and implications for the health care industry definition of advanced medical imaging. https://www.health.ny.gov/facilities/public_health_and_health_planning_council/meetings/2013-07-17/docs/2013-07-03_adv_diag_imag_backgrnd_papers.pdf. Accessed June 21, 2017.

OCE OCEBM Levels of Evidence Working Group; Oxford Centre for Evidence-Based Medicine. The Oxford 2011 Levels of Evidence. http://www.cebm.net/index.aspx?o=5653. Accessed July 31, 2017.

SMI Smith-Bindman R, Miglioretti DL, Johnson E, et al. Use of diagnostic imaging studies and associated radiation exposure for patients enrolled in large integrated health care systems, 1996-2010. *JAMA.* 2012;307(22):2400-2409.

Development Group

- Jordan Albritton, PhD, MPH
- Benjamin Fox, MD
- James Hellewell, MD
- Robert Hoesch, MD, PhD
- Jeremy Hopkin, MD
- Andrew Knighton, PhD, CPA
- Alyssa Lettich, MD
- Elisabeth Malmberg, MS
- Julie Martinez, MSN, RN, CCRP
- Heidi Porter, PhD (Medical Writer)
- Krista Schonrock, MD
- Laura Sittig, PhD (Medical Writer)
- Stephen Warner, MD
- Keith White, MD

This CPM presents a model of best care based on the best available scientific evidence at the time of publication. It is not a prescription for every physician or every patient, nor does it replace clinical judgment. All statements, protocols, and recommendations herein are viewed as transitory and iterative. Although physicians are encouraged to follow the CPM to help focus on and measure quality, deviations are a means for discovering improvements in patient care and expanding the knowledge base.

Intermountain® Healthcare

Intermountain Healthcare developed and endorses the Appropriate Use Criteria contained in this Care Process Model as a Provider-Led Entity qualified by the Centers for Medicare and Medicaid Services. Patient and Provider Publications CPM3002 - 12/20