Caring is Sharing – Exploiting the Value in Data for Health and Innovation
M. Hägglund et al. (Eds.)

doi:10.3233/SHTI230118

Automating Structured Results Communication to Expedite Imaging-Directed Care in Spine Oncology

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Abstract. Cancers frequently metastasize to the spine, where they can cause severe morbidity, including pain, vertebral collapse, and paralysis. Accurate assessment and timely communication of actionable imaging findings are critical. We developed a scoring mechanism to capture the key imaging features of examinations performed to detect and characterize spinal metastases in patients with cancer. An automated system was developed to relay those findings to the institution's spine oncology team to expedite treatment. This report describes the scoring scheme, the automated results communication platform, and initial clinical experience with the system. The scoring system and communication platform enable prompt, imaging-directed care of patients with spinal metastases.

Keywords. Oncology, Radiology, Results communication, Structured reporting, Common Data Elements

1. Introduction

Metastasis to the spine is a frequent complication of many forms of cancer: it is estimated that more than 30% of cancer patients will develop spinal metastasis [1]. Spinal metastases can cause severe pain due to nerve compression or vertebral collapse, and can result in paralysis due to compression of the spinal cord. The proper management of patients requires a timely multi-specialty approach [2,3]. Therefore, it is important that spinal metastases be communicated promptly to the physicians who can manage the disease. Even in a tertiary care medical center, where the medical staff order, perform, and interpret spine imaging examinations promptly, there can be unintended delays in communicating actionable findings to the neurosurgeons, orthopaedic surgeons, and radiation oncologists who are prepared to treat the disease.

The Spine Instability Neoplastic Score (SINS) and the Epidural Spinal Cord Compression (ESCC) scale provide imaging and clinical characteristics that are critical in treatment decision-making in patients with spinal metastatic disease, and have been validated in clinical practice [4-7]. We created a scoring scheme based on magnetic resonance imaging (MRI) features of SINS and ESCC for spinal column stability and

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cord compression; we omitted clinical features, such as mechanical pain, and imaging features that would be difficult to determine on MRI, such as the lytic or blastic nature of the metastases. We also developed and implemented a novel system to expedite highly detailed information about spinal metastatic disease to our institution's Spine Oncology treatment team.

2. Methods

2.1. Spine Oncology Imaging Score

In collaboration with our institution's spine surgeons, neurologists, and radiation oncologists, the radiology department formulated the Spine Oncology Imaging Score (SOIS) to highlight discrete MRI features from the SINS and ESCC scoring methods. To make SOIS readily available for use by the radiology department, we encoded it as a text "macro" within the institution's radiology reporting system (Nuance PowerScribe 360, Microsoft, Redmond, WA). By invoking the "Spine Oncology" macro, a radiologist can incorporate predefined text into the radiology report of a spine MRI examination. The text macro includes pick-list fields that allow selection of discrete common data elements to capture the SOIS components (Table 1).

Table 1. Components of the Spine Oncology Imaging Score.

Component	Values
Location	Rigid spine (S2-S5): 0 points Semi-rigid spine (T3-T10): 1 point Mobile spine (C3-C6, L2-L4): 2 points Junctional spine (Occiput-C2, C7-T2, T11-L1, L5-S1): 3 points
Alignment	Normal: 0 points Deformity (kyphosis/scoliosis): 2 points Subluxation: 4 points
Collapse	None: 0 points No collapse with > 50% vertebral body involvement: 1 point < 50%: 2 points > 50%: 3 points
Posterior elements	None: 0 points Unilateral: 1 point Bilateral: 3 points
Compression grade	Grade 0 (osseous disease only) Grade 1a (epidural involvement without thecal sac deformity) Grade 1b (thecal sac deformity without cord contact) Grade 1c (thecal sac deformity with cord contact) Grade 2 (cord compression with preservation of some CSF) Grade 3 (cord compression with complete effacement of CSF) Grade 4 (intramedullary/cord or drop metastasis) Grade 5 (intradural and extradural)

2.2. Notification system

To promote rapid dissemination of actionable imaging findings to the appropriate care team, we instituted an automated notification system that is invoked hourly. Scripts in Perl version 5.24.1 on a Linux x86-64 platform incorporated three Perl modules:

DBI::data to connect to the main database, MIME::Lite to send notification emails, and HTML::Template to compose emails in HTML. Data for the emailed notifications was compiled using a stored procedure written in the Structured Query Language (SQL). The stored procedure first searches the Nuance PowerScribe 360 (Microsoft, Redmond, WA) production database for any studies where the Spine Oncology macro was used. The script also searches the report text of all spine MRI exams for the string "[SOIS21]." For reports that meet the search criteria, the alert messages include the patient's name and medical record number, current location, and full text of the imaging report (Figure 1). The alerts are transmitted as secure electronic mail messages within the institutional environment protected by a multi-layer firewall; as all treatment specialists belong to the same healthcare organization, no external communication is made.

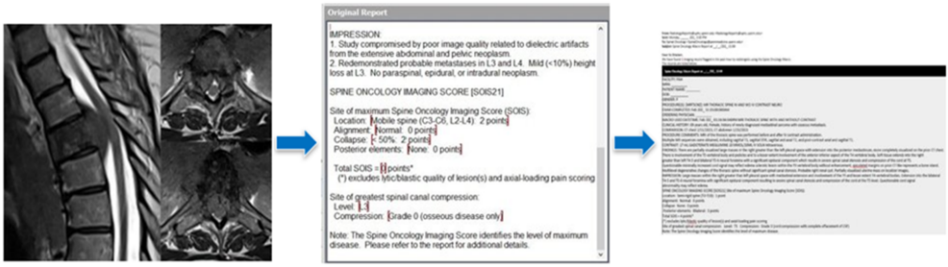

Figure 1. Sample workflow. Sagittal and axial MR images of the thoracic spine demonstrate a new T5 vertebral body metastasis with epidural spinal cord compression. The radiologist incorporates the SOIS macro into the radiology report. Less than an hour after the report was rendered, a secure electronic message is transmitted to the spine oncology specialists.

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SPINE ONCOLOGY IMAGING SCORE [SOIS21]
  Site of maximum Spine Oncology Imaging Score (SOIS): T11
  Location: Junctional spine (Occiput-C2, C7-T2, T11-L1, L5-S1): 3
        points
  Alignment: Normal: 0 points
  Collapse: > 50%: 3 points
  Posterior elements: Bilateral: 3 points

Total SOIS = 9 points*
(*) excludes lytic/blastic quality of lesion(s) and axial-loading pain
        scoring

Site of greatest spinal canal compression: Level: T11
Compression: Grade 3 (cord compression with complete effacement of CSF)

Note: The Spine Oncology Imaging Score identifies the level of maximum
disease. Please refer to the report for additional details.
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Figure 2. Portion of an example report showing use of the Spine Oncology text macro.

3. Clinical Implementation

From April 2021 to January 2023, the SOIS macro was incorporated into 1017 MR imaging exams of the cervical, thoracic, or lumbar spine in 431 patients; 491 of the exams (48%) were in female patients. 161 exams were referred from the emergency department,

365 on inpatients, and 490 on outpatients (Figure 3). Distribution by age of reports incorporating the Spine Oncology macro is shown in Figure 4.

Radiologists incorporated the Spine Oncology text macro into all relevant radiology reports, and the automated system functioned properly to send electronic notifications to the spine oncology multidisciplinary team within 1 hour of either the preliminary or final radiology report.

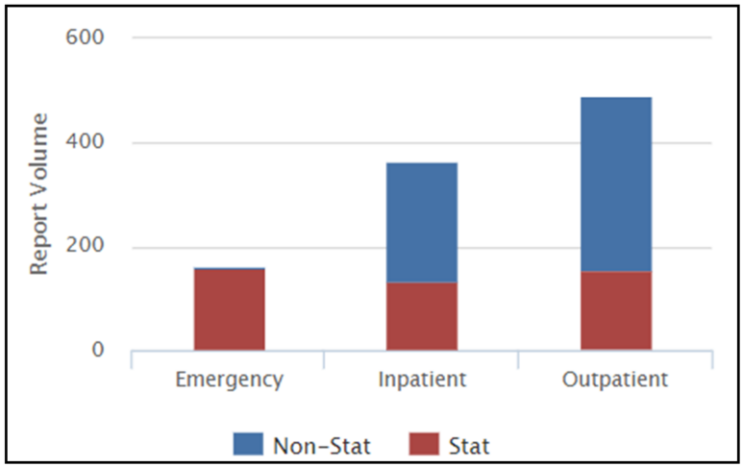

Figure 3. Distribution of exams by patient-care setting for reports that included the Spine Oncology text macro.

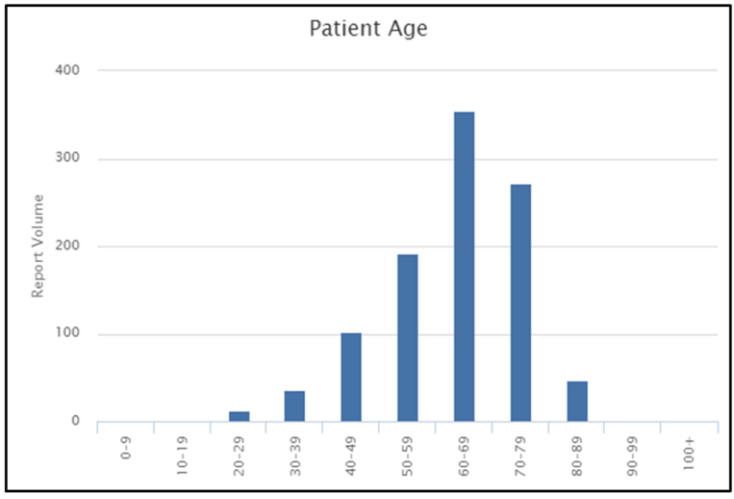

Figure 4. Distribution of exams with Spine Oncology reporting by patient age.

4. Ongoing Work

The Spine Oncology text macro includes a "tracker code"—an arbitrary sequence of letters and digits within square brackets, here "[SOIS21]"—which enables on-demand retrieval of relevant reports. A radiology report text-search system (Nuance mPower, Microsoft, Redmond, WA) retrieves reports that include the tracker code (and hence, the

Spine Oncology macro) for any specified time period. The data available for retrieval are updated every 24 hours. For exams flagged with the Spine Oncology macro, the management plan and outcome of each patient are reviewed and discussed at a weekly multidisciplinary conference. The use of the SOIS macro for more than 1,000 examinations in our multi-hospital tertiary academic institution is a testament to its utility across the several specialties that provide care to patients with spinal metastasis.

SOIS data elements, as part of the ESCC scale, have been incorporated into a library of Common Data Elements (CDEs) for radiology (https://radelement.org/set/RDES21), developed by the Radiological Society of North America (RSNA) and the American College of Radiology (ACR) [8]. CDEs define the attributes and allowable values of a unit of information, so that data can be collected and stored uniformly across institutions and studies. The RadElement.org data dictionary defines radiology CDEs is to make these data interoperable for a variety of applications, including clinical reports, computer-aided reporting systems, computer vision applications, clinical research report forms, and radiology case collections.

5. Conclusion

The Spine Oncology Imaging Score system, together with the electronic referral pipeline, has been technically successful and practical in automating referrals. By generating an electronic notification shortly after the radiology report is generated, the time interval between imaging and consultation is significantly reduced, which has enabled expedited and seamless patient care of these patients with time-critical imaging findings. The simple, image-based oncology score not only adds value but directs care to cancer patients with an unstable spine.

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