Advanced Radiographic Practice in Adult Chest Imaging

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Visiting Lecturer & PhD Student – Canterbury Christ Church University, Kent, UK
Primary aim of all Radiology Departments?

Patient focused service

Quality imaging service for primary care: a good practice guide

Francis 2013 HMSO; Royal College of General Practitioners et al. 2013; Swensen & Johnson J Am Coll Radiol 2010;7:216
Overview

- Why advanced radiographer practice?
- Justification of imaging requests
- Image acquisition & quality
- Why radiographer image interpretation?
- Evidence base: Radiographer reporting
- Contribution to patient care
Why advanced radiographer practice?

- Justification of imaging requests
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What is an Advanced Practitioner?

- Registered radiographer
- Postgraduate study & mentorship
- Defined scope of practice
- 4 key domains
Why Advanced Practitioner Radiographers?

- Radiographers fundamental to the diagnostic pathway
- First practitioner to see the image
- Provide complete service: justification – acquisition – interpretation
- Why advanced radiographer practice?
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Justification of Medical Exposures

- Legislation in UK regarding medical radiation exposures: IR(ME)R 2000
- Referring clinician required to explain clinical benefit, detailed to enable exposure
- Radiographers act as gatekeepers
Why advanced radiographer practice?
Justification of imaging requests
Image acquisition & quality
Why radiographer image interpretation?
Evidence base: Radiographer reporting
Contribution to patient care
Image Acquisition & Quality

- Request queries
- Assist/mentor junior radiographers & assistant practitioners
- Initial interpretation
- Plain imaging queries & patient questions
- Lead quality audits
Why advanced radiographer practice?
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Contribution to patient care
Evolution of Radiographer Image Interpretation

- Swinburne (1971) “pattern recognition” by trained radiographers
- Berman et al. (1985) “red dot” for MSK trauma
Why advanced radiographer practice?
Justification of imaging requests
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Evidence base: Radiographer reporting
Contribution to patient care
Evidence Base – Skeletal

- Piper et al. (2005) Structured exam: 27 radiographers; ~2,700 x-rays; sensitivity (93%), specificity (92%) and accuracy (93%)

- Piper et al. (1999) Multisite clinical evaluation: 10 radiographers; 7,170 reports; accuracy 97% - 99%

- Brealey et al. (2005) Meta-analysis provided definitive evidence: 28,900 examinations; 92% sens 97% spec
Evidence Base – Chest X-rays

- Sheft et al. (1970) Cancer detection in CXR image bank: 100 cases; 2 radiographers – 4 & 8 FN, 2 radiologists – 7 & 8 FN
- Flehinger et al. (1978) Clinical evaluation: ~3,000 x-rays; 2 radiographers; Low FN errors (2% & 3.2%) when reading with consultant radiologists
- Sonnex et al. (2001) ‘Red Dot’ system in specialist hospital; High sensitivity (90%) & specificity (99%)
From Abnormality Detection to Definitive Reporting
Chest X-rays – Definitive Radiographer Reports

- Piper et al. (2014) Structured examination: 40 radiographers, 4,000 CXRs; 95% sensitivity & specificity, 89% agreement

- Woznitzka et al. (2014) Clinical audit: 100 cases; 1 radiographer, 3 consultant radiologists; high concordance 92% ($K = 0.83$), 96% ($K = 0.91$), 96% ($K = 0.91$)
Robust Clinical Audit with Independent Expert Chest Radiologists
Chest X-rays – Agreement of Experts

- Random stratified sample of CXRs
- Two independent expert consultant chest radiologists, blinded to clinical report
- Reports compared for agreement: Kappa [K] and McNemar statistics
- 193 cases included; 79 (41%) normal clinical report
Total = 193 cases

- Expert 1 Normal: Total = 49
- Expert 2 Normal: Total = 87
- Expert 1 Abnormal: Total = 113
- Expert 2 Abnormal: Total = 75

Both Normal: n = 48
Both Abnormal: n = 74
Radiographer total = 40

Expert CC1 total = 25

ALL n = 24

n = 10

Expert CC2 total = 36

Normal

Abnormal

Radiographer total = 57

Expert CC1 total = 49

n = 3

ALL n = 34

n = 3

Expert CC2 n = 38
Radiologist total = 38
Expert CC1 total = 55
n = 1

Radiologist total = 38
Expert CC1 total = 23
n = 14

ALL n = 40
Expert CC1 total = 55
n = 11

ALL n = 22
Expert CC2 total = 35
n = 14

Abnormal

Radiologist total = 58
Expert CC2 total = 41
n = 11

Expert CC2 total = 35
n = 11

Normal
Observer Agreement: Experts & Clinical Report

Experts & Radiologists = 84%

Inter-Expert = 75%

Experts & Radiographers = 81%
Observer Agreement: Kappa

Kappa Statistic

- CC1-RR: 0.64, p < 0.001
- CC2-RR: 0.61, p < 0.001
- CC1-CR: 0.68, p < 0.001
- CC2-CR: 0.66, p < 0.001
- CC1-CC2: 0.52, p < 0.001
Observer Agreement: Experts & Radiographer Clinical Report

Radiographer
- Total: 97
- Combined: n = 43
  - Expert CC1: total = 80
    - n = 12
  - Expert CC2: total = 83
    - n = 12

Radiologist
- Total: 96
- Combined: n = 42
  - Expert CC1: total = 79
    - n = 17
  - Expert CC2: total = 81
    - n = 14

Expert CC2
- Total: 83
- Combined: n = 19
  - Radiographer: n = 19
  - Radiologist: n = 9

Expert CC1
- Total: 80
- Combined: n = 12
  - Radiographer: n = 7
  - Radiologist: n = 9

Observer Agreement:
- Combined: n = 43
- Radiographer: n = 12
- Radiologist: n = 10
Report Agreement: Experts & Clinical Report

CC1 = Expert 1  CC2 = Expert 2  RR = Reporting Radiographer  CR = Consultant Radiologist
Rigorous Assessment of Chest X-ray Diagnostic Accuracy: Comparison between Consultant Radiologists and Reporting Radiographers
Diagnostic Accuracy – Adult Chest X-rays

- 10 consultant radiologists & 11 reporting radiographers
- 106 adult chest x-rays with robust reference standard diagnosis
- Normal reporting conditions
- Reporting radiographers must be comparable to consultant radiologists
Diagnostic Accuracy – Figure of Merit

Observer Performance

- Radiologist average performance 0.79 (0.76 – 0.81)
- Radiographer average performance 0.83 (0.81 – 0.85)

$t = 11.585; p < 0.001$
Pathology: False Positives

<table>
<thead>
<tr>
<th>Feature</th>
<th>Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cardiomegaly</td>
<td>RR 71, CR 57</td>
</tr>
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</table>

# Pathology: False Positives

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<td>RR</td>
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<td>71</td>
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<tr>
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<td>52</td>
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<td>Unilateral Consolidation</td>
<td>52</td>
</tr>
<tr>
<td>Chronic Obstructive Pulmonary Disease</td>
<td>40</td>
</tr>
</tbody>
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Pathology: False Negatives

<table>
<thead>
<tr>
<th>Feature</th>
<th>Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unilateral Pleural Effusion</td>
<td>36 32</td>
</tr>
</tbody>
</table>

Pathology: False Negatives

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<tr>
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<tr>
<td>RR</td>
<td>CR</td>
</tr>
<tr>
<td>Unilateral Pleural Effusion</td>
<td>36</td>
</tr>
<tr>
<td>Interstitial Opacification</td>
<td>19</td>
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<td>Unilateral Pleural Effusion</td>
<td>36 32</td>
</tr>
<tr>
<td>Interstitial Opacification</td>
<td>19 22</td>
</tr>
<tr>
<td>Hilar Enlargement</td>
<td>14 15</td>
</tr>
</tbody>
</table>

Case 109

Radiographers 8/11 = 72%
Radiologists 6/9 = 67%

Case 107

Radiographers 8/11 = 72%
Radiologists 7/10 = 70%
<table>
<thead>
<tr>
<th>Lesions</th>
<th>Reporting Radiographers (n=11)</th>
<th>Percentage Correct</th>
<th>Consultant Radiologists (n=10)</th>
<th>Percentage Correct</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>All 3 lesions</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>20</td>
<td>rib lesions (x3) = myeloma</td>
</tr>
<tr>
<td>1-2 lesions</td>
<td>7</td>
<td>63.6</td>
<td>4</td>
<td>40</td>
<td>missed in clinical practice by CR</td>
</tr>
<tr>
<td>No lesions</td>
<td>4</td>
<td>36.4</td>
<td>4</td>
<td>40</td>
<td></td>
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</tbody>
</table>
Why advanced radiographer practice?
Justification of imaging requests
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Contribution to patient care
Contribution to Patient Care

- Patient focused care
- Rapid rise in workload
- Political/economic climate
Contribution to Care: Service Evaluation

Woznitza et al. (2014) Service evaluation at single department

- Retrospective interrogation of Radiology Information System
  - Efficiency: Waiting Times, Radiographer Reports
  - Effectiveness: Report Turnaround Time, Discrepancies
Efficiency: Waiting Time by Modality

Average Wait in weeks

- CT
- MR
- US

Data points showing the average wait time in weeks for CT, MR, and US modalities from April 2010 to February 2013.
Efficiency: Proportion of Reporting Radiographer & Sonographer Output

- **CT**
  - 2010-11: <1%
  - 2011-12: <1%
  - 2012-13: <1%

- **MRI**
  - 2010-11: <1%
  - 2011-12: <1%
  - 2012-13: <1%

- **US**
  - 2010-11: 52%
  - 2011-12: 51%
  - 2012-13: 52%

- **XR**
  - 2010-11: 49%
  - 2011-12: 58%
  - 2012-13: 59%
Efficiency: Radiographer Reporting

Proportion of Radiographer Reports

<table>
<thead>
<tr>
<th></th>
<th>2010-11</th>
<th>2011-12</th>
<th>2012-13</th>
</tr>
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<tbody>
<tr>
<td>MSK XRs</td>
<td>71</td>
<td>71</td>
<td>72</td>
</tr>
<tr>
<td>CXRs</td>
<td>13</td>
<td>34</td>
<td>41</td>
</tr>
</tbody>
</table>
Effectiveness: Safe Practice?

<table>
<thead>
<tr>
<th>Observer &amp; X-ray Type</th>
<th>Error Grade &amp; Number of Errors</th>
<th>Grade 2</th>
<th>Grade 3</th>
<th>Grade 4</th>
<th>Grade 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>RR MSK</td>
<td></td>
<td>4</td>
<td>2</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>CR MSK</td>
<td></td>
<td>0</td>
<td>1</td>
<td>6</td>
<td>1</td>
</tr>
<tr>
<td>RR CXR</td>
<td></td>
<td>0</td>
<td>1</td>
<td>7</td>
<td>1</td>
</tr>
<tr>
<td>CR CXR</td>
<td></td>
<td>1</td>
<td>2</td>
<td>15</td>
<td>4</td>
</tr>
</tbody>
</table>

RR = Reporting Radiographer  
CR = Consultant Radiologist

Royal College of Radiologists 2007; Jolly et al. Med Educ 2001;35(S1):36
Effectiveness: Safe Practice?

Number of Errors

Perceptual

Cognitive

CR

RR

Donald & Barnard J Med Imag Radiat Oncol 2012;56:173
Effectiveness: Report Turnaround Time

Reduction in departmental RTAT across the study period

One-way multivariate analysis of variance demonstrated mixed results

Significant reduction MRI RTAT for the study period (p=0.002),
CT RTAT also decreased, however not statistically significant (p=0.216)

Average X-ray RTAT increased between 2011-12/2012-13 (p<0.001)
Conclusions

- Advanced radiographer practice improves patient care
- Growing evidence base for radiographer adult chest reporting
- Radiographer reporting contributes to patient focused radiology service
Acknowledgements

- College of Radiographers Research Award
- Mr. Keith Piper – PhD Supervisor
- Prof. Graham Bothamley, Dr. Stephen Burke and Dr. Narendra Aladangady – Research and Clinical Mentors
- Ms. Kate Grayson and Dr. Sabina Hulbert – Statistical Advice
- Research participants – Radiographers & Radiologists
Questions?

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