Radiology assistants – models, roles and scope of practice: a rapid review

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An **Evidence Check** review brokered by the Sax Institute

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This rapid review was brokered by the Sax Institute.

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Introduction

This review examines the potential for radiology assistants to undertake some tasks that are currently part of radiologist roles and provides context for application to the Australian situation.

EXECUTIVE SUMMARY

Summary of key findings

The following key points identify the issues surrounding workforce productivity and reform for advanced roles conducted by radiographers:

- Advanced practice roles can overcome workforce deficiencies and provide improvements to patient outcomes
- Radiographers can perform advanced roles at the level of the radiologist with appropriate experience and training. There is some evidence that cost savings occur with advanced roles
- Accuracy and timeliness of medical imaging diagnosis directly affects health care costs and quality of patient outcomes. Strategies to improve accuracy and timeliness in medical imaging procedures and reporting will create better overall outcomes. Some evidence exists demonstrating improvement in accuracy and timeliness with advanced roles
- Clear boundaries (protocols) for practice and stringent accreditation for specified advanced roles, ensures quality and reduces the possibility of adverse legal implications
- A collaborative approach to training and defining protocols for practice is essential to creating confidence in the skill and knowledge level of those taking advanced roles
- Education provision requires a theoretical component and clinical training to ensure knowledge and practical skills at an appropriate level
- Successful implementation requires government intervention to remove current barriers to professional boundaries and collaboration between professional groups.

In summary, radiographers can perform tasks that are traditionally the role of the radiologist with timeliness and quality, and overcome workforce shortages or shortcomings in healthcare efficacy such as delayed reporting (diagnosis). Investment in breaking down barriers and creating pathways for implementation would be required. A change to Medicare fees and the wage for advanced roles may be necessary.

1 Overview

Advanced practice roles in radiography where the radiographer takes on specific tasks of the radiologist, have been successful in the United Kingdom (UK) for almost 20 years, and about 10 years formally in the United States of America (US). It is important to note that the extended tasks are quite different in the UK compared to the US.

Radiologist workforce shortages and an increasing demand for radiology services have been the primary drivers for role expansion of the radiographer.[1] In the UK, benefits have been derived from radiographers taking specific reporting and procedural roles whereas in the US only procedural role extension exists. Overall evidence indicates that radiographers with at least five years of general experience and additional training in advanced roles produce a quality of work that is similar to the radiologist. There is some evidence that cost and efficiency are improved with advanced roles.

The Medicare schedule fee for procedures conducted by radiographers in advanced roles may need revision. This may reduce the cost of some procedures carried out by these personnel as compared to radiologists who are more expensive workers.

Clear boundaries (protocols) for advanced practice roles must be defined to ensure quality and reduce the possibility for adverse legal implications such as negligence.[2] Working within accepted protocols designed on best practice, at an appropriate standard and taking all due care would provide a solid defence against a claim of negligence.[3]

Support from the radiologist professional body is helpful in introducing advanced roles but government intervention appears key to removing barriers to its inception.[4] A collaborative approach to training and defining protocols for practice is essential to creating confidence in the skill and knowledge level of those taking advanced roles. Training development and implementation should include radiologist and radiographer professional bodies, and educational providers. The proposed Institute of Clinical Education and Training, and the Clinical Innovation and Enhancement Agency as proposed in the Garling report, may be the appropriate institutions to oversee the process.

There is very little data regarding the value of information technology in supporting the use of radiology assistants in Australia.

2 Settings

The vast majority of research into advanced roles of radiographers has been conducted in the UK and US. There are key differences in these settings which may influence the interpretation of the data regarding radiology assistants and its applicability to Australia. Radiography is typically defined as either 'diagnostic' which includes X-ray, CT, magnetic resonance imaging (MRI), nuclear medicine (including positron emission tomography) and ultrasound or 'therapeutic' which relates to radiation therapy.

The base qualification in the UK for diagnostic radiographers is an undergraduate degree (Bachelor level) with postgraduate qualifications in nuclear medicine and ultrasound. In the US qualifications range from a certificate to degree with no uniformity across the nation.[5] In Australia the base qualification is an undergraduate or Master's level degree specifically in diagnostic radiography (X-ray, CT, and MRI), nuclear medicine or radiation therapy. Ultrasound is a postgraduate qualification commonly following diagnostic radiography or nuclear medicine.

The UK has a public system of health care with very little private radiography practice and nothing equating to Medicare whereas the US has Medicare and a mixture of public and private radiology practice which is similar to the Australian situation. Legal implications such as vicarious liability with role expansion may be different in public versus private practice.

Advanced practice roles, their value and use, are reported in diagnostic radiography, ultrasound, nuclear medicine and radiation therapy. This review has focused on diagnostic radiography only, but it should be noted that the efficacy of expanded roles is applicable to the other disciplines. Workforce size in Australia, as determined by the Australian Bureau of Statistics 2006 Census data, is: diagnostic radiography n=5972, sonography n=2126, nuclear medicine technologists n=503 and radiation therapy n=1306.

3 Definitions

Terminology for advanced practice i.e. roles which are usually performed by the radiologist and are beyond the scope of a baseline radiographer are inconsistent and do not equate to the same level of role or responsibility in different countries.

The US has two classifications for radiographers taking different levels of extended roles – 'radiologist assistant' and 'radiology practitioner assistant'.[6] The radiology practitioner assistant takes on higher order tasks. The UK uses the classifications 'advanced practitioner' and 'consultant practitioner'.[7] The consultant practitioner is a higher level classification.

In Australia, the Australian Institute of Radiography[8] has adopted the same terms as the UK for its advanced practice model.

This review will use the term 'advanced practice' as a general term relating to a new tier of practice where the radiographer is taking on tasks that typically would be performed by the radiologist. The US and UK terms will be used as applicable. No common term can be used as they infer different levels of expanded roles.

4 Method

Search strategy

The methodology as described in the Cochrane Handbook for Systematic Reviews was the principle used in this review of radiology assistants. This involves a comprehensive search of multiple databases, screening of titles and abstracts to determine which articles match the criteria for the review, followed by a full text examination of identified articles. Methodological rigour and applicability to the review criteria are ascertained on full text examination.

The databases Embase.com and Web of Knowledge (Medline) were used with a keyword search limited to articles in English, with abstracts, on humans and from 1998 to the present. These databases were chosen for the initial search because they provide a more comprehensive coverage of biomedical data from Europe and elsewhere. The search trees are slightly different thereby picking up additional data.

In order to establish the thoroughness of the screening process, more specific searches were conducted using the databases Pubmed and Google Scholar. A total of 226 articles were added to an EndNote library with 51 of these being identified as useful to this review. Not all articles are directly referred to in the report.

A brief review was conducted on the topic areas of offsite reporting by radiologists and stent procedures being conducted by radiologists. An EndNote library was created with 12 articles of which four are referred to in this review.

Articles for inclusion

Given the scope of the review aims, a broad range of study designs were acceptable. Prospective, retrospective, comparative studies, survey, systematic reviews and discussion papers were included. After full text reading the article was classified in one of four areas – quality, training, efficiency and structural issues e.g. legal. In most cases, the more rigorous methodologies had been used in papers relating to quality and efficiency. Discussion papers typically covered training and structural issues. These were valuable in providing contextual information and broadening understanding of the issues around advanced practice. Of the 51 articles, 21 were classified as quality or efficiency.

Table of studies

Two tables have been presented in this report – efficiency and quality. Findings from discussion papers reporting training and structural issues have been referred to where appropriate in the written section.

Each table provides an overview of the key information. Please note that in many cases there is overlap of information between the categories.

Efficiency n=3

Abbreviations								
R	= radiographer	**CR**	= consultant radiologist	**Abn**	= abnormal	**A&E**	= Accident and emergency
AP	= advanced practitioner	**Rad**	= radiologist	**N**	= normal	**NHS**	= National Health Service
RA	= radiologist assistant	**RR**	= radiologist registrar	**Ca**	= cancer	**US**	= ultrasound
RPA	= radiology practitioner assistant	**GP**	= general practitioner	**Std**	= standard	**NM**	= nuclear medicine

Efficiency	Country	Task	Method	Results	Key points
Blakeley C, Hogg P et al. Effectiveness of UK radiographer image reading. Radiol Technol 2008;79(3):221–226.	UK	Reporting by radio-graphers accuracy and turnaround time	Two accredited image reporting Rs. Retrospective analysis of 100 cases compared to CR. Turn around for reporting used a before and after design. Qualitative interviews to assess management issues	The two image-reading Rs had sensitivity (true positive rate – disease present) of 92.7%, specificity (true negative rate – disease absent) of 99.1% and diagnostic accuracy of 97% compared to the CR In 2004 – of examinations Rs were able to report, 76.4% of reports were generated by the Rs and 23.6% by Rads Reporting time turnaround – before mean turnaround time 10.23 days (SD 7.65). After implementation, mean 5.62 days (SD 4.27)	Accuracy consistent with published literature and local CR. Turnaround time almost halved for reports given by Rs. Qualitative analysis found a good working relationship and improved patient care
Brown L, Desai S. Cost-effectiveness of barium enemas performed by radiographers. Clin Radiol 2002:57(2):129–131.	UK	Performing barium enemas	Prospective study – R with five years experience and CR performing 200 barium enemas (out-patients) – three months (100 each). Time for procedure recorded	No significant time difference to perform the procedure between groups. A cost saving of 23% was made with the R performing the 100 barium enemas. In this NHS trust 1500 barium enemas are performed annually by the R (saving £5715)	It was cost effective using Rs to perform barium enemas. Senior Rs have been performing out-patient barium enemas since 1995. Note this is limited to outpatients
Ludwig R, Ferrara TL. What is your radiologist assistant student worth to you? J Am Coll Radiol 2008;5(2):115–118.	US	Productivity of eight RA students during their education (internship)	Retrospective data over two years. The eight RAs had an average of nine years general experience and 1700 internship hours (clinical)	A mean of 581 procedures performed by each RA. The range of potential professional fee reimbursement for the procedures performed by each student was $43,484 to $72,613. The mean potential reimbursement for the study sample was $58,957 and the median was $58,277	Efficiency and some cost effectiveness demonstrated. The authors note – once students complete education and established themselves productivity would be assumed to rise. Tasks performed were: informed consent, performing fluoroscopy, performing more invasive procedures requiring image guidance and conducting post-procedural patient evaluations

Quality n=18

Abbreviations								
R	= radiographer	**CR**	= consultant radiologist	**Abn**	= abnormal	**A&E**	= Accident and emergency
AP	= advanced practitioner	**Rad**	= radiologist	**N**	= normal	**NHS**	= National Health Service
RA	= radiologist assistant	**RR**	= radiologist registrar	**Ca**	= cancer	**US**	= ultrasound
RPA	= radiology practitioner assistant	**GP**	= general practitioner	**Std**	= standard	**NM**	= nuclear medicine

Quality	Country	Task	Method	Results	Key points
Benham JR, Culp WC et al. Complication rate of venous access procedures performed by a radiology practitioner assistant compared with interventional radiology physicians and supervised trainees. J Vasc Interv Radiol 2007;18(8):1001–1004.	US	Intravenous (IV) access complication rates	Retrospective review n=2093 procedures by four different operator groups (interventional radiology faculty members, interventional radiology fellows, radiology residents, and RPAs)	RPA performed 670 procedures. No statistical difference between operator groups. The complication rate for RPAs well below acceptable level	Quality equal Improved workflow especially with radiologist shortage. 40–50% of the daily work requires IV access 270 certified RPAs in US. These individuals have an average of eight years experience before RPA certification. On average 1800–2000 clinical hrs of training for certification
Booth AM, Mannion RAJ. Radiographer and radiologist perception error in reporting double contrast barium enemas: a pilot study. Radiography 2005;11(4):249–254.	UK	Reporting double contrast barium enema (DCBE)	Pilot study. Blinded comparison of accuracy of report. Three Rs vs three CR for 50 DCBE examinations (purposively selected retrospectively). Three Rs had minimum five years experience	No significant difference between sensitivity and specificity for either group. 52 Abns missed by the six participants. 41 false positives. No obvious statistical perceptual error difference between groups	Quality – this study showed no difference in perceptual error (a failure of detection). It notes double reading missed fewer abnormalities. The study was valuable in informing a larger study. Study had limited external validity due to the small figures in the study

Quality	Country	Task	Method	Results	Key points
Bradley AJ, Rajashanker B et al. Accuracy of reporting of intravenous urograms: a comparison of radiographers with radiology specialist registrars. Clin Radiol 2005;60(7):807–811.	UK	Reporting and performing intravenous urograms	Comparison – prospective analysis of 149 consecutive reports. Two groups – Three APs and RR compared to CR (gold Std)	Significant difference (p=0.021) in reporting accuracy between groups. APs were most accurate. A highly significant trend with seniority, APs with more years experience were more accurate. Final report correlated with CR	AP quality better than RR and performed the procedure with a high degree of technical quality. In-house training provided for APs who had 15–20 years experience
Brandt A, Andronikou S et al. Accuracy of radiographer reporting of paediatric brain CT. Pediatr Radiol 2007;37(3):291–296.	South Africa	Interpreting paediatric brain CT in emergency for triage	Comparison of two Rs against CR. Prospective analysis of 95 cases over one month of a wide range of case types. Assessed detection of Abns, significant Abn and insignificant Abn	90% of cases identified correctly as N or Abn R1 missed 38% of significant Abn. R2 worse	Quality of performance not sufficient to be used but authors suggest training may help. No formal training was provided when assessed. Instigated as a result of staff shortages
Brealey S, King DG et al. Accident and emergency and general practitioner plain radiograph reporting by radiographers and radiologists: a quasi-randomized controlled trial. Br J Radiol 2003;76(901):57–61.	UK	Reporting A&E plain radiographs	Quasi-randomised controlled trial. Retrospective stratified sample of 400 A&E and 400 GP plain radiographs of all parts. Body area stratified. Two APs against a CR. Used receiver operator characteristics to assess performance	No significant difference (0.09) in accuracy between CR and APs although CR better and there were some differences in APs	Implication of findings is that APs could report A&E plain radiographs in additional body areas than are currently permitted. These APs had been reporting specific appendicular radiographs since 1995 (prior to study) and had undertaken formal training. Representative and valid sample of studies included although inclusion of more subtle cases would have been better. Participants did not have access to prior results which impacts on interpretation and accuracy
Brealey S, Scally A et al. Accuracy of radiographer plain radiograph reporting in clinical practice: A meta-analysis. Clin Radiol 2005;60(2):232–241.	UK	Reporting plain radiographs	Meta-analysis to determine: accuracy of R against ref Std, accuracy of trained R and radiologists against ref Std; how	All studies included in review were in A&E with some additional orthopaedic and outpatients. Years of training reported and accuracy of	Quality and training. No difference in reporting accuracy of plain radiographs in a clinical setting. 37/256 NHS trusts where R report plain radiographs. The authors raise the point that most

Quality	Country	Task	Method	Results	Key points
			accurately selectively trained Rs report different pts and body parts; training programmes alter accuracy	reporting No difference in accuracy with varying seniority for all body parts. No difference when not in A&E i.e. orthopaedics and outpatient departments. Training significantly improved accuracy when reporting normal skeletal radiographs	research uses the CR as the reference whereas this may not be the most accurate. Authors note that introducing R reporting also affects clinicians' decision-making and patient outcomes, the availability of reports and the associated costs. Studies show that Rs commenting on plain radiographs do not adversely affect patient management or outcome and improve the availability of reports; and the costs range from nil to £15,000 per annum
Brealey S, Scally A et al. Accuracy of radiographers red dot or triage of accident and emergency radiographs in clinical practice: a systematic review. Clin Radiol 2006;61(7):604–615.	UK	Red dot (interpretation) accuracy triage in A&E	Systematic review to determine: accuracy of radiographer red dot and triage against ref Std; how accurately radiographers red dot or triage for different body parts; if training improve accuracy	Red dot* – Rs correctly identify N at a significantly higher proportion than Abn Triage – significantly lower proportion of chest and abdomen triaged accurately as compared to skeleton (only one study). Body area changes accuracy Training – no significant difference in accuracy with or without training *Red dot is where the R marks a radiograph in A&E to alert the possibility of the presence of an Abn	No strong evidence that red dot and triage are of value. Red dot implemented in 150 hospitals. Triage identifies if normal, insignificant Abn or significant Abn. Surveys have identified poor reporting turnaround in A&E Questionable findings regarding training because the same types of films were used before and after training. A number of the studies had inadequate reference stds therefore limitations when interpreting results. Acceptable error rates of red dot and triage are unclear. Authors note that reporting by Rs has less error than red dot or triage
Cowan I, Smith T et al. Developing the image interpretation skills of South Pacific radiographers: a joint	South West Pacific Islands	Radiographer as a dual reporter	Descriptive. A three-year project to improve medical imaging. Collaborative World Health Organization,	Initial summative assessments in interpretation throughout the course found five participants scoring less than 50%, the others ranged from 54	Implemented as a result of Rad shortages. Rs have a certificate or diploma qualification (very different to Australia). Currently a high degree of

Quality	Country	Task	Method	Results	Key points
WHO/RANZCR/ISRRT project. Australas Radiol 2007;51(6):527–531.			the Royal Australian and New Zealand College of Radiologists and the International Society of Radiographers and Radiologic Technologists 23 participants with 15 radiographers	– 85%. Interestingly four Rs outperformed one Rad. Note the results do not strictly relate to image interpretation	perception error hence the reason for dual reporting. Many Rs work without a Rads on site and the R is asked by local Drs to give a radiological opinion Three annual courses of two weeks each in plain film imaging of the musculoskeletal system, the chest and the abdomen, including intravenous urography Article included because it demonstrates where Rs are already used informally in interpretation
Crawley MT, Booth A. Reducing dose at barium enema: radiographers do it digitally. Br J Radiol 2002;75(896):652656.	UK	Performing barium enema – new protocol	Comparison of radiation dose and diagnostic accuracy using a modified protocol. Three groups – four specially trained Rs compared against CR and RRs. Rs had mobile and out-patients whereas Rads had over 75 year-old patients and inpatients (more difficult patients)	Dose for both groups reduced with new protocol and removed earlier disparity. No difference between Rs and CRs. Diagnostic accuracy not compromised by Rs performing the procedure. No Cas missed by this group The dose levels between Rs were not different however there were statistical differences between Rads	Quality – Rs perform modified protocol with less radiation dose and same accuracy as Rads. Rs have proven to be just as accurate performing barium enemas but the earlier protocol lead to a higher dose for patient
Duijm LEM, Groenewoud JH et al. Introduction of additional double reading of mammograms by radiographers: effects on a biennial screening programme outcome. Eur J Cancer 2008;44(9):1223–1228.	Nether-lands	Reporting mammogram	Comparison of reporting accuracy over two units. All 21 Rs participated with experience from 1–124 months. 78,325 mammograms read by R pairs after study completed. Screening Rads	Double reading by Rs alone would have resulted in detection of 4.5 per 1000 screened whereas Rad pairs were 5.25. Ca detection rate increased by 7% with double R reading	Raised detection using double radiologist and double Rs (four staff). Rs detected fewer Cas than Rads. Overall conclusion ambivalent due to some limitations. Double reading can increase Ca detection by 15%. Rad shortages mean this is not possible. Computed assisted diagnosis software not as good detection as double

Quality	Country	Task	Method	Results	Key points
			read independently as pairs. Two-year follow-up		Rad reading
Duijm LE, Louwman MW et al. Inter-observer variability in mammography screening and effect of type and number of readers on screening outcome. Br J Cancer 2009;100(6):901–907.	Nether-lands	Reporting mammogram	Comparison – inter-observer variability with two-year follow-up. Prospectively studied 106093 mammograms. 21 screening Rs with a range of 1–124 months experience and eight screening Rads with 39–95 months experience. Double read by two Rs and double read by two Rads (blinded)	Single reading by Rads resulted in considerable individual variation of Ca detection (sensitivity range 51.5–75%, mean sensitivity 63.9%) but no correlation with experience. Double reading by Rads increased the mean Ca detection rate and significantly improved sensitivity (mean sensitivity 68.6%). Single Rad and double R reading resulted in significantly increased referral rate and a higher Ca detection rate (mean sensitivity 75.2%). Double reading by Rads and Rs had the highest referral rate, Ca detection and sensitivity (mean sensitivity 76.9%)	Improved detection and referral rate with triple and quadruple readers. Authors note that having only experienced Rs would be better but this study included all screening Rs. Authors note that the Rads were all experienced and read a high volume of studies which is probably why no correlation found with experience although there was high single reader variability. Study not fully blinded therefore some bias may be introduced
Law RL, Slack N et al. Radiographer performed single contrast small bowel enteroclysis. Radiography 2005;11(1):11–15.	UK	Performing and reporting small bowel enteroclysis	Retrospective comparison – 10 years (1413 reports). Three specialist Rs with 5, 8, 20 years experience. Double reported – R and CR	R and CR reporting had an overall 99.3% concordance. No significant difference in sensitivity between groups	Quality and efficiency improved because of a better functioning team approach. The authors note the importance of having the CRs accepting the Rs role extension and relaxing boundaries

Quality	Country	Task	Method	Results	Key points
Law RL, Slack NF et al. An evaluation of a radiographer-led barium enema service in the diagnosis of colorectal cancer. Radiography 2008;14(2):105–110.9.	UK	Performing and reporting of double contrast barium enema (DCBE) for colorectal cancer.	Prospective study comparing (1997 to end of 2004) accuracy and sensitivity of Rs performance and reporting to CR report.	100% correlation between Rs and CRs evaluation of diagnostic categories. The only difference was in the grammar of the report.	Quality and efficiency – authors note that the requirement for double reading of DCBE performed by Rs may be unnecessary because when the Rs are appropriately trained and adhere to appropriate protocols they can accurately perform and report in a timely manner. Rs performing DCBE since 1986 in this NHS trust. Authors note that service delivery and patient outcomes need to be good or better when provided by the R in order for the Rad to devolve responsibility
Law RL,Titcomb DR et al. Evaluation of a radiographer-provided barium enema service. Colorectal Dis 2008;10(4): 394–396.	UK	Performing and reporting of double contrast barium enema for colorectal Ca	Prospective analysis of 224 cases. Three Rs performing and reporting (1 of 5 categories in the report). Compared with radiologist	100% concordance between R and Rad reporting and note that the current protocol of double reporting may be unnecessary. No improvement in diagnostic yield with double reporting	Quality and cost – Timely accurate performing and reporting by R only. Cost-effective with a 25% saving with Rs. Rs who are appropriately trained and adhere to protocols can accurately perform and report. Authors note the importance of seeking areas where radiologists aren't able to fulfil the role therefore more likely to devolve for role expansion

Quality	Country	Task	Method	Results	Key points
Smith TN, Traise P et al. The influence of a continuing education program on the image interpretation accuracy of rural radiographers. Rural Remote Health 2009;9(2):1145.	Australia	Interpreting musculo-skeletal plain radiographs by Australian rural radiographers	Before and after continuing education by distance for four months. Sent electronically with no clinical history. 400 cases with three grades of difficulty. Rs gave three levels of response – general opinion (1), observations (2), open comment (3)	16 Rs. Rs accuracy did not reach 85% (of what was considered agreement with radiologist) before or after training. Two of the three levels of response were statistically significantly different after training (general opinion and observation). Grade 2 and 3 cases significantly improved with training	Quality and training. Education helped but a longer session is needed for a more sustained learning. Difficulty in describing their opinion which would indicate a clear area that needs further education to raise ability. Rs double reading with non radiologist emergency physicians raise the overall accuracy of reporting
Sonnex EP, Tasker AD et al. The role of preliminary interpretation of chest radiographs by radiographers in the management of acute medical problems within a cardiothoracic centre. Br J Radiol 2001;74(879):230–233.	UK	Red dot (possible Abn identification) for pre and post – operative chest radiographs	Analysis of accuracy of red dot. Rads used as reference std. Six months 8614 plain radiographs	22% incorrectly red dotted (Rs erred on the side of caution). 0.5% should have been red dotted and were not. Rs correctly identified 4/5 radiographs with a significant Abn	Fairly good accuracy and useful in focusing on those films for early reporting. Authors comment that training would enhance accuracy. Only 70% of radiographs reported within 24hrs, 90% in three days in this institution. Authors point out red dot doesn't give diagnostic information and with slow reporting isn't as useful as possible R reporting. Initially red dot not well accepted but now it is. A problem with red dot is that sometimes the films without a red dot are very delayed in reporting
Van Valkenburg J, Ralph B et al. The role of the physician extender in radiology. Radiol Technol 2000;72(1):45–50.	US	Perform GI fluoroscopic procedures	15 RPA students with a minimum of five years experience (in 10 States). Each student took 142 random cases (including US and NM) and completed an evaluation – documented patient history and current symptoms, completed	Overall accuracy of 88% for all cases (evaluation). Lowest accuracy in NM 75%. Accuracy improved with years of experience. 7% of incidental findings missed. Survey results – Rads support these roles being taken; contrast injections 60%, interfacing with technologists to avoid interruptions 49%,	During 1997 – 9,815students enrolled in RPA University program. Authors suggest additional training for experienced Rs provide a valuable resource to current workforce situation. A barrier noted by the authors is the perception by Rads that this will take some work from newly graduated Rads but the authors feel this is unfounded because of the high

Quality	Country	Task	Method	Results	Key points
			imaging, documented his/her findings. Accuracy of evaluation form assessed. In addition, a small survey was conducted to ascertain Rads view of the mid level appointment	performing fluoroscopy 48%, patient assessment and management 46%, providing technical reports 38%, separating N from Abn cases 18%. A few reported RPAs improved their productivity. Overall 51% felt mid level position required and helpful in allowing them more time for image interpretation	demand in image interpretation that is not easily met. There is an interdependence of Rs and Rads therefore extended roles are a natural progression. The authors note that resistance to RPAs by radiologists is as a result of turf invasion
Wivell G, Denton ER et al. Can radiographers read screening mammograms? Clin Radiol 2003;58(1): 63–67.	UK	Mammogram interpretation	Analysis of accuracy and time for two Rs who had completed University PG certificate in interpretation. Retrospective study – re-reading of 1000 mammograms and identifying if further assessment required because of a potential abnormality. Blind to each other's opinion. Time taken to perform reading was counted. 7 participants (three Rs and four CRs)	Rs identified all Ca that CRs did. No significant difference between detection of different grade tumours. Rs appear more skilled at detecting calcification and small Cas than CRs. CRs better at larger Ca	Quality and time. Well trained Rs can perform to a satisfactory level with double reading. Rs perform in the same time as CRs. Double reading of mammograms improves accuracy by up to 15%. Shortages have meant that double reading not always possible with Rads

5 Benefits of advanced practice

Radiologist workloads have risen with factors such as technological developments in CT and MRI creating larger and more intensive volumes of work.[10] The UK CT scanner evaluation centre reports technological advances in CT have enabled "multi-slice scanners to scan long scan lengths with narrow slice widths"[11] hence producing a larger volume of images for the radiologist to read.

In the US, CT imaging from 2003–2007 increased from 16.3% to 20% of the total workload and MRI from 4.8% to 5.5%.[12] In Australia, CT made up 9.4% of total services in the year 1999–2000, while in 2003–2004 it was 11.4%. MRI in the same period went from 1.6% to 2.3%.[13] The Australian Medical Benefit Statistics indicate a 35% rise in CT between the years (financial calendar year) 2001 and 2006.

These developments may have altered the radiologist workflow and exacerbated delays in film reporting. In 2001, Sonnex et al.[14] reports 70% of studies were reported in 24 hours and 90% within 3 days at their institution. A recent Australian publication refers to one to three days typical delay in rural and metropolitan reporting.[15] The accuracy and timeliness of diagnosis has a direct implication to the cost of health care and the quality of patient outcomes.[16] A retrospective audit of image reading accuracy in a UK emergency department found diagnostic accuracy of 97% for two radiographers qualified to read appendicular and axial skeleton examinations compared to the consultant radiologist.[17] The reporting of examinations the radiographers were qualified to report rose from 36.7% in 2003 to 80.4% in 2004. Before the radiographers commenced reporting the mean turnaround time for reports was 10.23 days (SD 7.65) whereas after it dropped to 5.62 days (SD 4.27). Strategies to improve accuracy and timeliness in medical imaging will create better overall outcomes.

Radiographers taking on procedural (not reporting) advanced practice roles can perform the duties at a level of expertise and timeliness comparable to radiologists.[9,18–23] When procedures such as giving intravenous injections and barium swallows, meals and enemas are taken by advanced practitioners it allows more time for the radiologist to complete other duties thereby creating a more efficient workflow. A cost saving is found with radiographers performing barium procedures because of an altered fee structure when performed by this group.[24-26] Brown and Desai[24] compared the cost for barium enemas performed by the radiographer (advanced practitioner) against radiologists by measuring the time taken for the entire examination and staffing costs. The mean time for 100 barium enemas performed by the radiologist was 25.7 minutes whereas the radiographer was 24.2 minutes (no significant difference). A saving of £381 (21.3%) was made with the radiographer performing the studies as compared to the radiologist.

Accuracy of medical imaging reporting with radiologists has been reported as being variable particularly in more difficult to read procedures such as mammography. Using radiographers in a dual reporting role with a radiologist in screening mammography, increases the detection of abnormalities and is achieved at a lower cost than using dual radiologist reporters.[27] Double contrast barium enemas is another area where double reporting has improved accuracy and therefore improved patient outcomes.[9,21,22,28]

Radiographers reporting in specific areas of practice such as plain radiographs in accident and emergency[29,30] and double contrast barium enemas for colorectal cancer provide a service that is equivalent to radiologists. In Bradley et al.'s study[19] very experienced advanced practitioners had a greater degree of accuracy than the registrars in training. It should be noted when viewing the literature reporting accuracy of radiographer reporting that they are often compared to radiologists as the gold standard. This may be flawed as the literature reports a high degree of

variability between readers. Ideally accuracy would be assessed against the radiologist and pathology findings or against a large bank of films with known pathologies.[16]

6 Downsides of advanced practice

There is little evidence to show that with a suitable base level of experience and specific training, that quality of care, efficiency or cost is compromised when advanced practice roles are conducted by radiographers.

A resistance by radiologists to allow advanced practice roles is often encountered and this may hamper the most effective use of the role.[31] In the US, reporting or interpretation of images is clearly not accepted as part of role expansion whereas in the UK this is an accepted role in specific areas e.g. accident and emergency plain radiographs. The differences in roles between these countries may be as a result of government intervention.

In the UK, the government brought reform to health care by removing professional demarcations. In the 1990s radiographers were allowed to report and National Health Service trusts were allowed to employ whoever had the skills for specific roles e.g. radiographers were reporting in specific radiologic areas in some trusts. A radiography skills mix working party (College of Radiologists, Society of Radiographers, the Chief Medical Officer and members of education and nursing sectors) was put together and in 2003 a four-tier service delivery model (radiography assistant, base radiographer, advanced radiographer, consultant radiographer) was introduced for radiography including nuclear medicine and radiation therapy.[7,34,35] The Royal College of Radiologists subsequently provided a document with information on guidance of the four-tier model[35] but did not have overarching authority as to what was allowed in advanced practice roles.

In the US, the American College of Radiology (radiologists) and the American Society of Radiologic Technologists (radiographers) worked together in 2003 to define the roles and responsibilities of advanced practice roles.[36] Government did not intervene and it would seem the advanced roles were governed more by the American College of Radiologists and what the radiologists were happy to give up i.e. allow radiographers to do.

Billing for procedures conducted by radiographers needs redesign for successful implementation. However this can bring savings to cost, as radiographers are less costly personnel than radiologists.[5,6,32] Thorwarth[33] reports physician costs are $1.78 per minute whereas technologists are $0.41. Given that radiographers are a less expensive worker than radiologist, tasks taken over by the radiographer will create cost savings. Public patients in public hospitals in Australia do not attract a Medicare fee for service therefore tasks performed by advanced practice radiographers will create cost savings. On the other hand, private patients in public hospitals do incur a Medicare fee and where a service has been performed by a radiographer instead of the current fee assuming that a radiologist has performed the procedure, a new billing code and altered fee may be required.

Advance practice roles may be at greater risk of litigation but if billing, coding and clear evidence-based guidelines for practice are established, then legal aspects associated with litigation are no more at risk than with radiologists.[41]A claim of negligence is the greatest risk for the advanced practitioner. If clearly accepted best practice guidelines have been established and a benchmark standard of care is established for advanced practitioners, then those working within these limits are at no greater risk than radiologists performing such tasks.[3,34] The Garling report for reform in NSW hospitals recommends the creation of a Bureau of Health Information where published measurements of clinical performance, safety and quality are published. The Bureau may be of value in setting such guidelines and benchmarks with the input from the Royal Australian and New Zealand College of Radiologists (RANZCR) and the Australian Institute of Radiography (AIR).

Initial defining and development of training programs for advanced practice roles requires funding and collaboration between all relevant bodies.[37] Radiographers taking on advanced practice roles will require a rise to their salary commensurate with the additional responsibility and training.

The use of the system 'red dot' does not appear to have substantial benefits to productivity and may in fact cause problems. The red dot system (radiographer abnormality detection system) was developed in England and put in place to try and overcome long delays in accident and emergency medical image reporting. Radiographers identify studies where an abnormality appears to be present; this in turn alerts the radiologist to place this study as a priority to report. In practice, this can lead to some studies never being reported and possibly influences the perception of the reporter prior to reading thereby introducing a bias to reporting.

7 Additional information

Information technology

There is very little reported about the effect of information technology on advanced practice. Computer assisted diagnosis (CAD) software has been used in screening mammography with limited value. Dual reporting with a radiologist and radiographer was found to be more beneficial.[38]

Offsite reporting

Picture archiving and communication systems (PACS) and teleradiology allow digital transfer of images so that remote reporting is possible. One five-year before and after study of the effects of PACS reported a 30% increase in productivity per month after PACS was implemented.[39] The effects of offsite reporting have not been well reported in the literature but one US study notes that sites with off hours teleradiology performed 27% more procedures than similar centres without this service.[12] A small qualitative study in Norway however reported a disadvantage with offsite reporting to be the reduced contact between radiologist and clinician.[40]

RANZCR report that the use of overseas reporting for a procedure carried out in Australia is unresolved as to whether a claim can be made through Medicare.[41] The 2005 Medicare Schedule indicates that only services rendered in Australia including reporting are eligible for payment but RANZCR indicate this may not be legally binding.

Australian situation

At this stage there are no formal advanced practice roles in Australia although AIR has produced a proposed model for advanced practice following the UK model.[8] The proposed model notes the following issues that need addressing for successful implementation:

- AIR policy for development and implementation of advanced practitioners and consultant practitioners
- Insurance – review of the professional indemnity insurance
- Education – expand postgraduate course or subject accreditation for the advanced and consultant practitioner roles
- Legislative changes – possible changes required to the radiation or drug acts and possible provider numbers or fee splitting through the Health Insurance Commission
- RANZCR –AIR may need to negotiate with the College for the development of such positions.

No substantial data exists as to the efficacy of advanced practice in rural or remote areas, although a small study evaluated accuracy interpreting musculoskeletal plain radiographs of Australian rural radiographers before and after continuing education.[15] Smith and Baird report that extending radiographers to take on reporting tasks may help reduce pressure on radiologists and that Australian education is of a high standard with universities being in a position to provide

postgraduate education in image interpretation.[42] The Garling report recommendation for introducing a NSW Institute for Clinical Education and Training for overseeing postgraduate training may be of value in monitoring the clinical aspect of the advanced or consultant practitioner education. Both the UK and US have used a two-year training model where one year is spent learning theory and the other is spent in clinical with a mentor onsite.

Radiographers in Australia have a uniform high level of education and anecdotally are readily employed overseas e.g. the UK. Given the improved reporting turnaround time and level of accuracy in the UK and Netherlands with advanced radiographers reporting e.g. double contrast barium enemas and mammography, it would seem logical that the Australian radiographer with appropriate training could achieve the same efficiencies and outcomes. Taking over procedures traditionally performed by the radiologist would bring cost savings and improved workflow by allowing the radiologist more time to perform other duties, particularly in light of the ever rising workload in CT and MRI.

Training and structure for advanced practice

In the UK a Masters level is expected for advanced practitioner roles and typically five years minimum experience as a radiographer. The consultant practitioner requires even greater experience with a suggested eight to ten years post registration and a minimum of three years as an advanced practitioner.[4,43] The training consists of didactic and clinical learning.[44] In the US onsite training is required for RAs and RPAs and some form of additional theoretical learning; this is variable throughout the nation. Ellenbogen et al.[6] report that one university has graduated 300 RPAs.

Success in creating a structure for advanced practice lies in a few areas. In the UK government policy allowing National Health Service trusts to employ whoever they felt were qualified to do the job was pivotal to breaking down barriers to advanced practice.[7] In the US agreement between the American College of Radiologists and the American Society of Radiologic Technologists as to what tasks could be undertaken in advanced practice was essential to use of these personnel. Interestingly, physician assistants (not radiographers) in the US have been in use in radiology for some time effectively taking roles similar to those that the UK advanced practitioner (radiographer) has.

Key factors to ensuring a high quality of practice by radiographers taking advanced practice roles are to[2,7,26,45,46]:

- Set clear boundaries of practice by creating protocols for practice which are kept up to date using evidence-based methods. This also helps with legal issues by defining accepted practice with defined levels of supervision for specific tasks/roles
- Have accreditation for the role that meets the equivalent standard of radiologists
- Ensure the radiographer continually updates and maintains skills in the advanced practice role
- Provide training that includes in-depth clinical knowledge as well as practical skills.

Stent surgery by radiologists

A brief review of the literature found no reports on the value of radiologists performing stent surgery. One small study reported a modified staffing approach where vascular surgeons were able to safely perform endovascular abdominal aortic aneurysm repair without the direction of a cardiologist or radiologist.[47]

8 Summary

The Australian setting with its uniform high entry level qualification for radiography (or other medical imaging disciplines) and current issues with managing radiologist workloads, presents an environment that the literature reports would benefit from advanced practice roles. Success however would be dependent upon the acceptance of the roles, stringent training, defined protocols, a restructure to salaries and billing for procedures.

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