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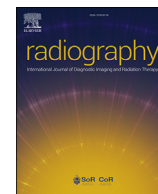
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Australian radiographers' approaches to mammographic imaging of women with cardiac implantable electronic devices

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ABSTRACT

Introduction: In the absence of Australian best practice standards, this study aimed to investigate Australian radiographers' approaches to mammographic imaging of women with cardiac implantable electronic devices (CIEDs) and to identify differences between the diagnostic and screening settings.

Methods: A survey was distributed amongst Australian radiographers with current or previous mammography experience. Questions explored whether CIED information was obtained via consent or questionnaire, the availability of CIED protocols, the views obtained, radiographer experiences, and exposure settings used. Descriptive analysis using percentages was undertaken. A chi-square test, with a significance level of $p < 0.05$, was used to compare differences between the screening and diagnostic settings.

Results: A sample of 220 radiographers demonstrated inconsistency and uncertainties in positioning approaches within and between radiographers and mammography settings and a knowledge gap surrounding the appropriate degree of compression for current and emerging CIEDs. Only 6 % had a consent form questioning if patients had a pacemaker or CIED; just 20 % had a site protocol to follow, with significantly higher rates in the screening compared to the diagnostic setting ($p = 0.017$; $p < 0.001$, respectively). When no protocol was available, the number of different imaging series increased from 13 to 19.

Conclusion: With no national guidelines or policies identified within Australia, radiographers appeared to lack a clear understanding of best practice imaging approaches for women with a CIED. The results of this study inform the urgent need to develop a foundation of best practice for mammographic imaging of women presenting with CIEDs.

Implications for practice: This study emphasises the importance of educating radiographers and creating national guidelines for safely performing mammography on women with CIEDs in Australia to address the risks posed by current knowledge gaps.

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Introduction

In Australia, breast cancer is the most diagnosed female cancer, with an incidence of 150 cases per 100,000 females in 2023.¹ Used to detect breast cancer, mammography is available through two distinct settings: screening and diagnostic. BreastScreen Australia (BSA) biennially screens asymptomatic women over the age of 40 years with a target age group of 50–74 years.² Symptomatic women, women aged under 40, and men can be referred for

diagnostic mammography at other facilities under Medicare, Australia's universal healthcare scheme.^{2–4} Routine mammography in both settings is performed by radiographers and consists of two projections: the craniocaudal (CC) and the mediolateral oblique (MLO) view.

The incidence of women undergoing mammography with a cardiac implantable electronic device (CIED) in Australia is unknown and under-reported elsewhere, with only one study describing pacemakers in less than 0.5 % of diagnostic mammography cases.⁵ However, a recent study found that pacemakers, implantable cardioverter defibrillators (ICDs), subcutaneous-implantable cardioverter defibrillators (S-ICDs) and implantable loop recorders (ILRs) are all CIED types being imaged in Australian mammography practice.⁶

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Irrespective of incidence rates, the coexistence of a CIED is associated with reduced efficacy of mammography.^{5,7} Patients with a pacemaker or ICD may have existing anxiety following their implant operation,^{8,9} as well as postoperative and chronic pain and restricted shoulder movement.^{10–12} As mammography requires sound shoulder mobility for proper positioning, and with the components of these devices often implanted within the field of view (FOV), it is foreseeable that a device may interfere with routine imaging. Further, during the mammogram the device may be subject to compression on average between 8 and 14 daN (motorised maximum 20 daN).¹³ Compared to imaging the breast without a CIED, radiographers have been reported to be fearful of compressing and damaging the device and compensated by using more caution, altering standard mammographic techniques, and reducing applied compression.^{5,7} This change to best practice imaging is important as optimal compression is fundamental to the production of high-quality images, with under compression risking increased radiation exposure, image blur and missed cancer.¹⁴

Paap et al. (2016)⁷ inference increased anxiety among radiographers as a response to increased patient pain and anxiety during mammographic imaging. Radiographers' elevated anxiety could be due to their own concerns about potential damage to the device during positioning and compression. Knowing what device a woman has inserted is essential to best managing both patient and radiographer anxiety and approaches to imaging.⁶ Identification of a CIED in situ is best achieved through written consent prior to imaging; however, little is known about this process.

Paap et al. (2016)⁷ and van der Stuijt et al. (2020)¹⁵ recommend the establishment of local (Netherlands) and international guidelines to reassure both patients and radiographers during mammographic imaging of women with CIEDs.⁷ Within Australia, no national guidelines or protocols pertaining to mammography of women with CIEDs were identified in a search of governing bodies, including BSA, the Cardiac Society of Australia and New Zealand (CSANZ) and the Royal Australian and New Zealand College of Radiologists (RANZCR). Without guidelines, best practice, including high-quality imaging and positive experiences for women with these devices, may be difficult to achieve.

Radiographer uncertainties around best practice imaging including compression force and patient fear and anxiety impact mammography practice and the mammography experiences of women with a CIED. However, the extent of these challenges in the context of mammography practice in Australia remains unknown. Additionally, a comparison between the diagnostic and screening settings has yet to be explored.

Methods

Radiography members of the Australian Society of Medical Imaging and Radiation Therapy (ASMIRT) were invited to complete a five-part survey online using SurveyMonkey™, which included open and closed questions: Part 1: Demographics; Part 2: Patient questionnaires, consent forms and imaging protocols; Part 3: Radiographer experiences; Part 4: CIED knowledge and awareness and Part 5: Image quality. The study methodology has been published in full elsewhere with the results of Parts 1 and 4.⁶ This paper reports Parts 2 and 3.

In Part 2, respondents were asked if the patient questionnaire or consent form at their clinical site specifically asked the patient if they had a pacemaker or other CIED; if their clinical site had a protocol specific to imaging women with a pacemaker or other CIED, what views were in the protocol and did they routinely follow this protocol. Respondents without a protocol were asked what views they routinely used.

Modelled on the Dutch study by Paap et al.,⁷ Part 3 used a Likert scale to investigate the rate at which radiographers experienced the following: how often mammography of women with CIEDs is being approached the same as women without CIEDs; their confidence in choosing the appropriate mammographic views when imaging women with CIEDs; were routine positioning views altered for women with a CIED compared to those without. Radiographers were also asked how often clients with a CIED asked questions about the safety of performing mammography with their device; had they noticed clients experiencing more pain during compression of the breast with a CIED; were they afraid of damaging the device during compression; were they more cautious; and if they routinely reduced compression in breasts with a CIED to avoid damaging the device. Respondents were then asked if they felt equipped with the knowledge and information to confidently respond to patient concerns and questions about safely performing mammography with CIEDs.

Data analysis was performed using IBM SPSS software version 28. Descriptive statistics (percentages) were used to assess radiographers' responses. A Pearson's chi-squared test was used to determine whether there was a statistically significant difference between screening and diagnostic mammography settings. The significance level was set at $p < 0.05$. Open-ended comments were analysed using simple thematic analysis.

Results

Two hundred and twenty surveys met the inclusion criteria and were subsequently analysed. The study sample represented a wide range of mammography experience, predominantly those with greater than ten years of mammography practice (60.9 %) and with mammography certification (65.8 %), with all States and Territories in Australia represented.⁶ As required by BSA,¹³ most screening respondents had an ASMIRT mammography-related certification, significantly higher than that of the diagnostic setting, who are not required by the accrediting body to hold certification (97.8 % vs 37.1 % respectively, $p < 0.001$). Demographic results have been reported elsewhere in full.⁶

Consent form

Only 5.9 % ($n = 13/219$) of respondents' site consent forms or questionnaires specifically asked if the patient has a CIED (Table 1). Of those, a significantly higher proportion was from the screening setting ($p = 0.017$). In open-ended comments, radiographers reported that the presence of a CIED needed to be declared on the consent form to best manage risk (Table 2, R#122, R#72, R#226).

Site protocol and views

Around one-fifth (20.1 %, $n = 44/219$) had a pacemaker or CIED site protocol, with significantly more protocols identified in the screening setting compared to the diagnostic setting (33.3 %, $n = 15/45$ vs 9.8 %, $n = 6/61$; 9.8 %; $p < 0.001$), respectively (Table 1). Of those with a protocol, around half (53.5 %, $n = 23/43$) followed it, while the other half (46.5 %, $n = 20/43$) selected that it depended upon patient presentation.

Routine CIED imaging views

Most respondents were confident they knew which mammographic views to take (80.2 %, $n = 163/208$ 'always' or 'often'), with significantly more ($p < 0.001$) screening respondents (64.3 %, $n = 27/42$) 'always' feeling confident of the views compared to those in the diagnostic setting (25.5 %, $n = 14/55$) (Table 1). No

Table 1
Survey responses reporting radiographers' approaches to mammography practice when imaging women with a CIED.

Statement/Question	Category of Mammography Setting Experience	Response, n (%)			Total n	p value
		Yes	No	Unsure		
Does/did your site patient/client questionnaire or consent form ask if the patient has a pacemaker or other CIED? <i>n</i> = 219	Screening	6 (13.3 %)	39 (86.7 %)	0	45	<i>p</i> = 0.017
	Diagnostic	1 (1.6 %)	60 (98.4 %)	0	61	
	Both	6 (5.3 %)	98 (86.7 %)	9 (8.0 %)	113	
	Total	13 (5.9 %)	197 (90.0 %)	9 (4.1 %)	219	
Does/did your site have a mammography-specific protocol for imaging women with a pacemaker or other CIED? <i>n</i> = 219	Screening	15 (33.3 %)	23 (51.1 %)	7 (15.6 %)	45	<i>p</i> < 0.001
	Diagnostic	6 (9.8 %)	53 (86.9 %)	2 (3.3 %)	61	
	Both	23 (20.4 %)	80 (70.8 %)	10 (8.8 %)	113	
	Total	44 (20.1 %)	156 (71.2 %)	19 (8.7 %)	219	
Statement/Question	Category of Mammography Setting Experience	Yes	No	Dependent on patient presentation	Total n	p value
		Yes	No	Dependent on patient presentation	Total n	p value
If yes, did you routinely follow this protocol? <i>n</i> = 44 (<i>one respondent did not answer</i>)	Screening	7 (46.7 %)	0	8 (53.3 %)	15	<i>p</i> = 0.577
	Diagnostic	2 (33.3 %)	0	4 (66.6 %)	6	
	Both	14 (63.6 %)	0	8 (36.4 %)	22	
	Total	23 (53.5 %)	0	20 (46.5 %)	43	
Statement/Question	Category of Mammography Setting Experience	Response, n (%)				p value
		Never	Sometimes	Often	Always	
I approach mammography of women with CIEDs in the same way as women without CIEDs. <i>n</i> = 207	Screening	7 (15.6 %)	12 (26.7 %)	15 (33.3 %)	11 (24.4 %)	<i>p</i> = 0.380
	Diagnostic	13 (22.8 %)	21 (36.8 %)	13 (22.8 %)	10 (17.5 %)	
	Both	34 (32.4 %)	27 (26.0 %)	31 (29.5 %)	13 (12.4 %)	
	Total	54 (26.1 %)	60 (29 %)	59 (28.5 %)	34 (16.4 %)	
I feel confident when choosing the mammographic views to take when imaging women with a CIED. <i>n</i> = 203	Screening	0 (0.00 %)	1 (2.4 %)	14 (33.3 %)	27 (64.3 %)	<i>p</i> < 0.001
	Diagnostic	3 (54.5 %)	15 (27.3 %)	23 (41.8 %)	14 (25.5 %)	
	Both	4 (3.8 %)	17 (16.0 %)	38 (35.8 %)	47 (44.3 %)	
	Total	7 (3.4 %)	33 (16.3 %)	75 (36.9 %)	88 (43.3 %)	
I alter the routine positioning technique more frequently for women with a CIED than for women without. <i>n</i> = 208	Screening	3 (6.7 %)	17 (37.8 %)	12 (26.7 %)	13 (28.9 %)	<i>p</i> = 0.496
	Diagnostic	2 (3.5 %)	19 (33.3 %)	23 (40.4 %)	13 (22.8 %)	
	Both	2 (1.9 %)	33 (31.1 %)	42 (39.6 %)	29 (27.4 %)	
	Total	7 (3.4 %)	69 (33.2 %)	77 (37.0 %)	55 (26.4 %)	

other variables differed significantly between the screening and diagnostic settings.

There were 13 different imaging series undertaken where site protocols were in place compared to 19 amongst those without a site protocol. Where site protocols were available, the most common imaging series (*n* = 12) mimicked breast augmentation imaging (with and without the CIED in the FOV) (Table 3). However, even with a site protocol in place, 31 respondents indicated that the imaging series they would use ultimately depended on patient presentation (Table 2, R#168). Conversely, where no site protocol was reported, the most common imaging series (*n* = 36) reflected routine imaging (CC and MLO) (Table 4). One hundred and seventeen respondents indicated that the series they would use again depended on patient presentation.

Patient reassurance

As shown in Table 5, most radiographers (88.8 %, *n* = 175/197) stated that they had been asked questions by patients concerning the safety of performing mammography with their CIED. A significant difference in distribution was shown between the two mammography settings and experiencing patient questions (*p* = 0.008). Approximately half of the screening workforce respondents (47.6 % *n* = 20/42) are 'often' asked questions compared to only 25 % (*n* = 13/52) of the diagnostic workforce. Conversely, a significantly higher proportion of the diagnostic workforce (19.2 %, *n* = 10/52) had 'never' been asked questions from women with a CIED compared to none of the screening workforce (0 %, *n* = 0/42,

p = 0.008). Approximately half of all respondents (49.2 %, *n* = 97/197) felt they lacked the information to respond to patient concerns and questions confidently (Table 2, R#15, R#80², R#120¹, R#195¹, R#107²). Where concerns are raised, the examination may be postponed, and patients directed to their general practitioner (GP) or cardiologist for advice (Table 2, #R80¹, #R47).

In comparing the screening and diagnostic settings (Table 5), a significantly higher proportion (*p* = 0.007) of the screening workforce (66 %, *n* = 28/42) felt equipped with the knowledge and information to answer questions compared to the diagnostic workforce (38.5 %, *n* = 20/52).

Radiographer experiences

Most radiographers indicated they feared damaging the device during compression (85.1 %, *n* = 167/196) (Table 2, R#34¹, R#35). Significantly, 28.8 % (*n* = 15/52) of those in the diagnostic settings were 'always' afraid of damaging the device compared to no one in the screening settings (0 %, *n* = 0/40) (*p* < 0.001). Over half (59.2 %, *n* = 116/196) 'sometimes' noticed increased pain in women with a CIED, while one quarter (25.5 %, *n* = 50/196) did not notice any increased pain (Table 5).

A statistically significant difference in distribution was found between the two mammographic settings and increased pain (*p* = 0.032). When modifying technique, 73.6 % of respondents are 'always' more cautious (*n* = 145/197), and 63.6 % (*n* = 126/198) of respondents 'often' or 'always' routinely reduce the degree of compression (Table 5) (Table 2, R#107, R#28¹). Respondents

Table 2
Themed key open-ended responses.

Theme	Comment
Awareness of the CIED prior to mammographic imaging	'Needs to be included on the consent form ... mammographers need to be made aware of CIEDs via a consent form prior to imaging as some are visibly unnoticeable and patients don't always remember to let you know of these devices.' (R#122, 6–10 y, screening & diagnostic) 'All clients/patients should have to declare on a form whether they have a device and additional information with informed consent including any risks should be provided to protect the imaging staff (like with breast implants).' (R#72, 11–20y, screening) '... will often refer to the patient's previous mammogram imaging to see if the device was included in the FOV and check what compression value was applied previously.' (R#26, 11–20 y, diagnostic)
Patient Experiences: Anxiety and concerns about damaging the device	'I personally think the main issue with imaging women with CIEDs is the anxiety of the patient. Many of them are convinced even the lightest amount of pressure will damage them or that the x-ray itself will cause it to malfunction. Once these anxieties are relieved, I generally don't have issues. (R#18 ¹ , 11–20 y, screening & diagnostic) 'I find most women with a device are extremely anxious about me compressing CIEDs if they are close/palpable under the skin. They request for it not to be compressed. Very concerned that it will be damage/loosen wires/affect their heart ...' (R#107 ¹ , >20 y, screening & diagnostic)
Compression: Concerns, current knowledge, adaptations and reassurance	'... I have limited understanding of what the devices can tolerate and how securely they are implanted' (R#34 ¹ , 11–20 y, screening & diagnostic) 'I always worry about pulling the wires out of the device on compression.' (R#35, >20y, screening & diagnostic) 'I am confident that the mammogram will not damage the CIED. I would assure the patient that I would use less compression just enough to obtain a diagnostic image.' (R#28 ¹ , 1–5 y, screening and diagnostic)
Guidance from interpersonal health professionals	'If a client is concerned about safety, the mammogram can be postponed whilst we gather information regarding the device they have, generally from their specialist.' (R#80 ¹ , >20 y, screening) 'If clients are concerned, I recommend they contact their GP or cardiologist to check if there are any recommendations against having a mammogram.' (R#47, 6–10y, screening)
Current CIED knowledge and awareness	'No workplace training on CIEDs was ever given at any of my 3 different mammography sites.' (R#15, 1–5y, screening & diagnostic) 'With some of the devices we see more often yes but there are always new devices and variations, so this is often changing making it harder for us to be fully equipped.' (R#80 ² , >20 y, screening) 'I have only come across the pacemaker arrangement in my 42-year experience so if there are other types possibly would need to be made aware by vendors!' (R#120 ¹ , >20 y, screening & diagnostic) 'I have not seen many of these devices before. I would not feel confident answering questions about some of them ...' (R#195 ¹ , 1–5y, screening & diagnostic)
Experiential knowledge	'Mammography is a dynamic examination. In my practice, it is normal to make micro-adjustments for body habitus. The presence of a CIED is another one of the individual presentations that determine my positioning technique in order to image maximum breast tissue.' (R#168, >20 y, screening & diagnostic)
Call for device-specific information, training, and guidelines.	The use of newer CIEDs is increasing but the mammo world hasn't kept up with readily available updates and protocols. I haven't seen all of the device types now available that are in this survey. More information about CEIDs and updated protocols would be fantastic.' (R#107 ² , >20 y, screening & diagnostic) '... will be nice if a more consistent approach towards mammography and CIED is taken.' (R#176, 11–20 y, screening & diagnostic) 'Education for mammographers regarding these devices and compression is needed, plus a pamphlet women with CIEDs can read ...' (R#175, 11–20 y, screening) 'Vendors need to provide info to all imaging sites.' (R#120 ² , >20 y, screening & diagnostic)

Note: R-respondent; # - participant number; y - years of experience

reported a limited understanding of devices and the amount of compression able to be applied (Table 2 R#34¹, R#35), as well as reporting that women often had extreme anxiety concerning the examination (Table 2 R#18¹, R#107¹). Radiographers called for vendor specific education and updated protocols to support a consistent approach to imaging of newer devices (Table 2 R#107², R#176, R#175, R#120²).

Discussion

This survey investigated Australian radiographers' approaches to mammographic imaging of women with a CIED and compared practices between the screening and diagnostic settings. The study confirmed that radiographers' approaches to imaging are influenced by the presence of a CIED, mirroring the study by Paap et al.⁷

Prior to any medical imaging in Australia, informed consent must be obtained. Medical imaging consent forms must include applicable information that aids patients in comprehending both the benefits and risks of examinations so that they can make an informed decision on whether to proceed with the procedure.¹⁶ Awareness of a CIED type and location prior to performing a mammogram through a consent form or patient questionnaire is also an effective tool for radiographers to best manage positioning, compression, and

exposure settings.⁷ However, this study revealed that only 5.9 % of respondents' consent forms explicitly asked if patients had a CIED. This potentially leaves radiographers to incidentally discover a CIED while performing the mammogram, such as on assessment of previous imaging, questioning women on visible lumps, scarring and palpable devices during imaging, or even too late when an image is taken. Informed consent inadequacies could result in radiographers being less prepared and liable to put patients at risk of experiencing complications and associated management not identified as potential risks on consent forms.¹⁶

Although pertaining to other imaging modalities, CSANZ recommends a protocol-based approach for medical procedures that may adversely impact the safety of those with a CIED.¹⁷ This study reported that only one-fifth of respondents had a pacemaker or CIED site protocol. In addition, this study found considerable inconsistency amongst these protocols. The substantial variability in the imaging series and the views routinely used is evidence of the need for protocols for best practice, as women should expect the same approach to imaging regardless of where their mammography is performed. Standardised protocols are integral to guiding consistent imaging practice and the delivery of high-quality, evidence-based imaging and patient care.^{18,19} Establishing standardised protocols and guidelines and device-specific safety information, training, and education may help keep radiographers

Table 3
Mammogram views routinely used where site protocols are in place.

View Combinations Used	1	2	3	4	5	6	7	8	9	10	11	12	13
CC: device in FOV, normal compression	•	•						•	•	•		•	
MLO: device in FOV, normal compression	•	•											•
CC: device in FOV, no/reduced compression			•	•									
MLO: device in FOV, no/reduced compression			•	•	•	•			•	•	•		
CC: device not in FOV, normal compression			•	•	•	•	•	•					
MLO: device not in FOV, normal compression		•	•	•		•	•	•	•		•		
LMO													
Other: Lateral with the device not in FOV instead of MLO													
Unsure (<i>n</i> = 3)													
Approach dependent on patient presentation (<i>only</i>) (<i>n</i> = 7)													
Routine views always dependent on patient presentation (<i>n</i> = 24) ^a													
No views listed (<i>n</i> = 12)													
Total number of respondents with this protocol	4	1	12	1	2	6	1	1	2	1	1	1	1

Note: CC - cranio-caudal view; MLO - mediolateral oblique view; LMO – lateromedial oblique view; FOV – field of view.

^a Comment offered in addition to views routinely used.

better informed as to evolving CIED technology and its implications on mammography practice.

Worth consideration is that protocols in medical imaging are prone to ad-hoc adjustments dependent on patient presentations and radiographer discretion and or professional judgement.^{19,20} This study found around two-thirds of the sampled radiographers would ‘often’ or ‘always’ deviate from routine positioning techniques. Adjustments to the approach to the routine views and additional views may be deemed appropriate as they are often dependent on patient presentation and body habitus, as well as an attempt to include as much breast tissue as possible.^{13,21} This may justify why half the respondents followed their site CIED protocol while the other half adapted positioning.

Correlating to the study by Paap et al.,⁷ the radiographers in this study experienced shared concerns about damaging the device, with most respondents reducing the degree of compression. However, for those few who responded in our study to ‘never’ reduce the compression in the breast with a CIED, it is unknown whether these patients have been placed at risk of damaging their devices. Lead and device dislodgment or malfunction, as well as malrotation or mechanical pulling of the device, are associated with high morbidity and cardiovascular mortality.^{22–24} Although reported incidents of complications in CIEDs associated with mammography are rare, mammography is thought to have been the cause of lead fractures, device dislodgment and pain requiring device review.^{7,25} This study

highlighted some misunderstandings and potential and serious risks of complications in current practice, including a comment suggesting attempted displacement of the position of the generator to move it out of the FOV, emulating the breast implant displacement (ID) technique (also known as the Eklund technique) used for breast augmentation imaging.²⁶ International guidelines advise mammography after six months post CIED implant and specifically not to directly compress or attempt to move the device or leads.^{27,28} The Dutch Expert Center for screening (LRCEB), advise extreme caution and a minimum compression force of 5 daN when compressing the breast with the CIED in the FOV, noting that the forces below may impact image quality and reduce specificity.²⁷

Another consideration for mammography practice in women with a CIEDs is the known association with increased pain, discomfort, and anxiety.^{7,15,29,30} Although patients were not surveyed directly in this study, we found radiographers noticed women experiencing more pain in the breast with a CIED than without during mammography. This supports previous studies, where patient anxiety has been attributed to a predominant concern over damaging the device during compression and a lack of information and uncertainty amongst performing radiographers.^{7,15}

The current study also found that most radiographers (85 %) experienced women with a CIED asking questions about the safety of performing mammography, suggesting a degree of concern and anxiety among our patients. Our study sought to identify if

Table 4
Mammogram views routinely used where site protocols are not in place.

View Combinations Used	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
CC: device in FOV, normal compression	•	•	•	•								•	•					•	
MLO: device in FOV, normal compression	•	•	•	•										•	•	•	•		•
CC: device in FOV, no/reduced compression					•	•	•												
MLO: device in FOV, no/reduced compression					•	•	•	•	•			•							
CC: device not in FOV, normal compression		•		•			•	•	•	•	•			•	•	•	•		
MLO: device not in FOV, normal compression		•	•	•			•		•	•	•	•	•		•	•	•		
LMO				•							•				•		•		
Other: Lateral with device not in FOV instead of MLO																			
Other: CC not in FOV with reduced compression																			
Unsure (<i>n</i> = 9)																			
Approach dependent on patient presentation (<i>only</i>) (<i>n</i> = 33)																			
Routine views are dependent on patient presentation ^a (<i>n</i> = 117)																			
No views listed (<i>n</i> = 40)																			
Total number of respondents who routinely used these views	36	8	2	1	7	1	11	7	17	18	2	1	3	14	1	1	1	1	1

Note: CC - cranio-caudal view; MLO - mediolateral oblique view; LMO – lateromedial oblique view; FOV – field of view.

^a Comment offered in addition to views routinely used.

Table 5

Survey responses reporting radiographers' approaches to patient safety concerns and care when imaging women with a CIED.

Statement/Question	Category of Mammography Setting Experience	Response, n (%)				Total n	p value
		Never	Sometimes	Often	Always		
I experience patients with a CIED asking questions about the safety of performing mammography with their device. <i>n</i> = 197	Screening	0	20 (47.6 %)	20 (47.6 %)	2 (4.8 %)	42	<i>p</i> = 0.008
	Diagnostic	10 (19.2 %)	25 (48.1 %)	13 (25.0 %)	4 (7.7 %)	52	
	Both	12 (11.7 %)	50 (48.5 %)	32 (31.1 %)	9 (8.7 %)	103	
I notice patients experience more pain during compression of the breast with a CIED compared to the breast without. <i>n</i> = 196	Total	22 (11.2 %)	95 (48.2 %) ¹	65 (33.0 %)	15 (7.6 %)	197	<i>p</i> = 0.032
	Screening	7 (16.7 %)	32 (76.2 %)	2 (4.7 %)	1 (2.4 %)	42	
	Diagnostic	18 (34.6 %)	24 (46.2 %)	7 (13.5 %)	3 (5.8 %)	52	
I am afraid of damaging the device during compression. <i>n</i> = 196	Both	25 (24.5 %)	60 (58.8 %)	12 (11.8 %)	5 (4.9 %)	102	<i>p</i> < 0.001
	Screening	11 (27.5 %)	20 (50.0 %)	9 (22.5 %)	0	40	
	Diagnostic	4 (7.7 %)	22 (42.3 %)	11 (21.2 %)	15 (28.8 %)	52	
I am more cautious when imaging patients with a CIED than without. <i>n</i> = 197	Both	14 (13.5 %)	39 (37.5 %)	33 (31.7 %)	18 (17.3 %)	104	<i>p</i> = 0.736
	Total	29 (14.8 %)	81 (41.3 %) ¹	53 (27.0 %)	33 (16.8 %)	196	
	Screening	0	1 (2.4 %)	8 (19.5 %)	32 (78.0 %)	41	
I routinely use less compression in breasts with a CIED to avoid damaging the device. <i>n</i> = 198	Diagnostic	1 (1.9 %)	1 (1.9 %)	13 (25.0 %)	37 (71.2 %)	52	<i>p</i> = 0.424
	Both	2 (1.9 %)	9 (8.7 %)	17 (16.3 %)	76 (73.1 %)	104	
	Total	3 (1.5 %)	11 (5.6 %)	38 (19.3 %)	145 (73.6 %)	197	
	Screening	2 (4.8 %)	16 (38.1 %)	15 (35.7 %)	9 (21.4 %)	42	<i>p</i> = 0.007
	Diagnostic	2 (3.8 %)	14 (26.9 %)	17 (32.7 %)	19 (36.5 %)	52	
	Both	7 (6.7 %)	31 (29.8 %)	34 (32.7 %)	32 (30.8 %)	104	
	Total	11 (5.6 %)	61 (30.8 %)	66 (33.3 %) ¹	60 (30.3 %)	198	<i>p</i> = 0.007
	Screening	28 (66.7 %)	14 (33.3 %)			42	
	Diagnostic	20 (38.5 %)	32 (61.5 %)			52	
Do/did you feel equipped with the knowledge and information to confidently respond to patients' concerns and questions about safety during mammography with CIEDs? <i>n</i> = 197	Both	51 (50.5 %)	52 (50.4 %)			103	<i>p</i> = 0.007
	Total	100 (50.8 %)	97 (49.2 %)			197	

radiographers felt equipped with the information and knowledge to respond in these situations. We found almost half (49.2 %) of radiographers in our study felt ill-equipped to respond to patient concerns or questions confidently. This may be due to a lack of knowledge and confidence in identifying CIED types, particularly the emerging S-ICD and the varied shapes of different ILRs.⁶ This evidences the urgent need for education to inform this scope of practice.

When comparing the two settings, significantly more screening-based respondents had protocol and consent form questions dedicated to a CIED than the diagnostic setting (*p* < 0.001; *p* = 0.017, respectively). Alongside the experience associated with the high volume of women imaged in BSA settings compared to diagnostic, having a protocol and knowledge of the device prior to the examination may be argued to produce variation between settings. Further, it may explain why the diagnostic setting workforce was significantly less confident in the views to take (*p* < 0.001) and why 28.8 % were 'always' afraid of damaging the device compared to none of the screening workforce (*p* < 0.001); and why screening respondents felt significantly more confident to respond to patient concerns around safety compared to those in the diagnostic setting (*p* = 0.007). These differences highlight areas of concern for mammography practice in the provision of a holistic service in both settings.

Limitations

Limitations of this study have been previously reported⁶ and include potential recall bias and limited CIED knowledge and awareness. Mammographic imaging of women with a CIED is not a common occurrence meaning respondents are relying on

retrospective encounters and details that may have lost clarity or been forgotten over time. It is also possible that respondents may have confused pacemakers with the similarly designed ICD.

Conclusion

For the first time, this research has provided a detailed insight into current Australian mammography practice amongst radiographers when imaging women with a CIED. Of concern, uncertainty, and inconsistency in practice amongst radiographers and between BreastScreen and diagnostic settings were evidenced in the study results. These results highlight the urgent need for the development of guidelines and policies to support best practices for imaging women participating in mammography and presenting with a CIED and for improved radiographer education.

Ethics statement

Ethics approval for this study was granted by the Charles Sturt University Human Research Ethics Committee (HREC) (Protocol number: H22042).

Conflict of interest statement

None

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QUESTIONNAIRE

A2(26) Part 1 of 2

Australian radiographers' approaches to mammographic imaging of women with cardiac implantable electronic devices

INSTRUCTIONS

- Read through the article and answer the multiple-choice questions provided below.
- All questions have only **ONE** correct answer

Question 1: What does CIED stand for?

- A:** Cardiac Imaging Evaluation Device
- B:** Cardiac Implantable Electronic Device
- C:** Clinical Imaging Enhancement Device
- D:** Central Imaging Equipment Device

Question 2: Which two mammographic views are routinely used?

- A:** Axillary and lateral
- B:** Craniocaudal and mediolateral oblique
- C:** Oblique and tangential
- D:** Anteroposterior and lateral

Question 3: What percentage of radiographers had a site protocol for imaging women with CIEDs?

- A:** 5%
- B:** 10%
- C:** 20%
- D:** 50%

Question 4: Which setting had significantly more site protocols?

- A:** Diagnostic
- B:** Screening
- C:** Emergency
- D:** Outpatient

Question 5: What was the most common reason for radiographers modifying compression techniques?

- A:** Poor image resolution
- B:** Patient anxiety and fear of device damage
- C:** Lack of training
- D:** Equipment malfunction

Question 6: What percentage of respondents had a consent form asking about CIEDs?

- A:** 5.9%
- B:** 15%
- C:** 25%
- D:** 50%

Question 7: What was the most common imaging series used without a protocol?

- A:** Augmentation views
- B:** Routine CC and MLO
- C:** Lateral only
- D:** MRI

Question 8: What percentage of radiographers feared damaging the device during compression?

- A:** 50%
- B:** 65%
- C:** 85.1%
- D:** 95%

Question 9: Which group felt more confident in choosing mammographic views?

- A:** Diagnostic radiographers
- B:** Screening radiographers
- C:** Emergency technicians
- D:** General practitioners

Question 10: What was the most common patient concern reported?

- A:** Radiation dose
- B:** Device malfunction during compression
- C:** Length of exam
- D:** Image quality

THE END

QUESTIONNAIRE

A2(26) Part 2 of 2

Australian radiographers' approaches to mammographic imaging of women with cardiac implantable electronic devices

INSTRUCTIONS

- Read through the article and answer the multiple-choice questions provided below.
- All questions have only **ONE** correct answer

Question 1: What percentage of radiographers felt unequipped to answer patient questions?

- A: 25%
- B: 49.2%
- C: 60%
- D: 75%

Question 2: What was the average compression force range used in mammography?

- A: 2–6 daN
- B: 8–14 daN
- C: 15–20 daN
- D: 20–25 daN

Question 3: Which organization oversees breast screening in Australia?

- A: CSANZ
- B: RANZCR
- C: Breast Screen Australia
- D: ASMIRT

Question 4: What percentage of screening radiographers held mammography certification?

- A: 50%
- B: 65.8%
- C: 97.8%
- D: 100%

Question 5: What was the most common radiographer response to patient anxiety?

- A: Refer to cardiologist
- B: Increase compression
- C: Cancel the exam
- D: Ignore concerns

Question 6: What was the most frequent modification made by radiographers?

- A: Changing exposure settings
- B: Reducing compression
- C: Using alternative views
- D: Skipping CC view

Question 7: What percentage of radiographers reported being more cautious with CIEDs?

- A: 50%
- B: 73.6%
- C: 80%
- D: 90%

Question 8: Which type of CIED was most commonly mentioned?

- A: ILR
- B: S-ICD
- C: Pacemaker
- D: CRT-D

Question 9: What was the recommended approach when no protocol was available?

- A: Use MRI
- B: Follow routine views
- C: Adjust based on patient presentation
- D: Refer to emergency

Question 10: What is the key implication of this study?

- A: Increase use of MRI
- B: Develop national guidelines for CIED imaging
- C: Reduce mammography exams
- D: Eliminate compression

THE END



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A2(26)

Australian radiographers' approaches to mammographic imaging of women with cardiac implantable electronic devices

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