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Research

Optimizing Projectional Radiographic Imaging of the Abdomen of Obese Patients: An e-Delphi Study

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ABSTRACT

Purpose: Obesity is increasing in prevalence globally, with increased demands placed on radiology departments to image obese patients to assist with diagnosis and management. The aim of this study was to determine perceived best practice techniques currently used in clinical practice for projectional radiography of the abdomen for obese patients with the aim to help elucidate areas for future research and education needs in this field.

Experimental Design: A two round e-Delphi study was undertaken to establish a consensus within a reference group of expert Australian clinical educator diagnostic radiographers (CEDRs). Initially, a conceptual map of issues regarding imaging obese patients was undertaken by analysing interview transcripts of 12 CEDRs. This informed an online questionnaire design used in Delphi rounds 1 and 2. A consensus threshold was set <75% "agreement/disagreement", with 15 and 14 CEDRs participating in rounds 1 and 2, respectively.

Results: Seven of the 11 statements reach consensus after round 2. Consensus on using a combination of higher peak kilovoltage (kVp) and milliampere-seconds (mAs) to increase radiation exposure increased source-to-image distance and tighter collimation was achieved. There was no consensus regarding patient positioning practices or patient communication strategies. The expert group reported the importance of personal confidence and treating patients as individuals when applying techniques.

Conclusion: Diversity of experts' opinions and current practice may be due to the variations in obese patients' size and presentation. Therefore, there is a need for extensive empirical evidence to underpin practice and education resources for radiographers when imaging obese patients.

RÉSUMÉ

But : L'obésité est de plus en plus répandue à travers le monde, et les services de radiologie sont de plus en plus souvent appelés à traiter des personnes obèses à des fins de diagnostic et de gestion des soins. Le but de cette étude est de déterminer les meilleures pratiques perçues actuellement utilisées en pratique clinique pour la radiographie projectionnelle de l'abdomen chez les patients obèses, dans le but d'élucider des champs de recherche et d'éducation futurs dans ce domaine.

Méthodologie expérimentale : Une étude Delphi électronique en deux étapes a été menée afin d'établir un consensus au sein d'un groupe de référence d'experts d'éducateurs cliniques en radiographie diagnostique (CEDR) australiens. Au départ, une carte conceptuelle des enjeux de l'imagerie des patients obèses a été réalisée par analyse de la transcription des entrevues 12 CEDR. Ceci a permis de produire un questionnaire en ligne utilisé dans les étapes 1 et 2 de l'étude Delphi. Un seuil de consensus a été fixé à <75% « accord-désaccord », avec 15 et 14 CEDR participant respectivement aux étapes 1 et 2.

Résultats : Sept des 11 énoncés on t produit un consensus après la deuxième étape. Un consensus a été obtenu sur l'utilisation d'une combinaison de kilovoltage de pointe (kVp) et de milliampère-secondes (mAs) pour augmenter l'exposition au rayonnement et la distance source-image et obtenir une collimation plus serrée. Il n'y a pas eu de consensus sur les pratiques de positionnement du patient ou les stratégies de communication avec le patient. Le groupe d'expert rappelle l'importance de la confiance personnelle et du traitement des patients comme des personnes dans l'application des techniques.

Conclusion : La diversité dans l'opinion des experts de la pratique actuelle peut s'expliquer par les variations de taille et de présentation

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chez les patients obèses. Par conséquent, il est nécessaire de recueillir une grande quantité de preuves empiriques pour appuyer les ressources de pratique et d'éducation des radiographes pour l'imagerie des patients obèses.

Keywords: Radiographers; obesity; education; best practice; clinical educators

Introduction

Obesity is increasing in prevalence globally, and in many countries, it is becoming an epidemic health issue [1]. The World Health Organisation [2] defines obesity as a chronic health condition that is characterised by a body mass index (BMI) of 30 and above. Obesity has a large impact on the health care system as it is associated with a number of comorbidities [3]. The serious health conditions related to obesity are linked to increasing demands on radiology departments due to the necessity of imaging to assist with diagnosis and management plans [4]. In Australia, 27.9% of the population aged 18 years and older are considered obese, with a further 35.5% of the population classified as overweight with a BMI greater than 25 [5]. An increasingly obese patient population is a major concern for the service provision of radiology and specifically, Australian diagnostic radiographers who provide imaging services directly to patients. Radiographers are required to adapt their radiographic exposure and positioning techniques to achieve diagnostic quality images for obese patients.

Projectional radiography is usually the initial diagnostic imaging modality for many patients [6], and with an escalating obese population, determining models of best practice is becoming increasingly important. Studies have reported that radiologists are finding it increasingly difficult to report on examinations of obese patients because of poor image quality caused by scatter radiation, poor photon penetration, and long exposure times [7]. The ability to achieve diagnostic images of obese patients is of great importance as reduced image quality and associated compromised diagnostic interpretation has been linked with longer hospital stays, potentially unnecessary procedures, and ultimately an increased cost to the individual as well as to the health care system [1]. The value of plain abdominal imaging for obese patients with abdominal complaints is questionable; it remains a common imaging choice because of lack of alternatives at the primary care level—ultrasonography lacks penetration and many CT units are unable to cater for very large patients, artefacts are more common, and higher volumes of iodinated contrast are required because of increased patient weight [8].

Although there have been many technological advances in general radiography resulting in increased automation, radiographers are still required to make a number of key imaging choices. The physical limitations of imaging equipment are a major consideration [7–9]. Actual patient size is also of concern in terms of covering the area of interest radiographically because of the limitation of commercially available image receptors, the largest usually being 43 × 35 cm [1,10]. Consequently, obese patients may require multiple images, compared with the average patient, to adequately assess the abdominal area. An example of this may be that the abdomen of an obese patient is often imaged with three 43 × 35 cm image receptors as opposed to a single image for a patient with a normal-range BMI [1]. This equates to a significant increase in radiation dose to the obese patient when compared with a patient at a BMI of approximately 25.

Another challenge faced by radiographers is that radiographic positioning is very tactile and relies heavily on palpating bones and locating surface landmarks to accurately position the patient for diagnostic images. The increased amount of adipose tissue for obese patients severely impedes the ability to identify anatomical landmarks as well as affecting the patient's mobility and ability to self-assist with positioning. It has been reported that student radiographers have especially found positioning obese patients and locating their anatomical landmarks challenging [11], and studies have reported that obese patients frequently have repeated imaging because of inaccurate positioning [6].

Radiographically, the prime challenges in imaging obese patients involves increased attenuation of the x-ray beam, scatter radiation, low-contrast images, and motion artefacts due to long exposure times [1,12]. The increased amount of adipose tissue attenuates a greater proportion of the x-ray beam creating images with a greater contribution from scatter radiation, which in turn decreases the visual contrast of the image. In obese populations, this may affect image quality even with more advanced digital imaging designed to autocorrect for image contrast.

To counter these effects, an increased exposure is often suggested as a method of best practice. However, the literature, both professional and educational, lacks a quantitative basis to determine by how much the exposure should be increased and this translates into a lack of strategy for radiographers to adapt their exposure technique. A variety of sources suggest increasing radiation exposure factors, such as peak kilovoltage (kVp) and milliampere-seconds (mAs), using a grid and implementing tighter collimation as ways that scattered radiation may be reduced [1,4,7]. A balance is necessary as increasing the kVp in order that enough photons get through to the receptor may also cause the image to lose further visual contrast because of reduced differential absorption from adjacent structures with differing attenuation properties, meaning a potential loss of information about specific anatomical structures and their boundaries [13]. Increasing the mAs through increased exposure time can create a motion artefact, and using a grid to reduce scatter radiation requires a further increase in the exposure factors to compensate for the radiation absorbed by the grid itself [6]. It is important that the techniques used when imaging obese patients is within the parameters of the "As Low As Reasonably Achievable" principle, and therefore, the compromise between the radiation dose to the patient and image quality needs to be consistent with diagnostic purpose [14,15].

Perhaps the only current standardised way to base exposure changes is the exposure indices used by modern digital imaging systems. However, there are limitations to exposure indices as these are kVp dependant, retrospective in nature and are based on algorithms assessing signal to noise ratio, independent of image contrast.

This study aims to explore what is currently considered as clinical best practice for projectional imaging of obese patients using an expert group of Australian diagnostic radiographer, with an eye to considering future areas of research that could benefit this field to optimise practice. This is a complex area of investigation, and owing to a paucity of literature surrounding evidence-based practices, it was decided that the scope would be limited to projectional radiography of the abdomen. The abdomen of obese patients presents one of the greatest challenges to the radiographer as it is the anatomical region that is usually most different in size/girth from the normal-range BMI population.

Methods

A modified e-Delphi (decision style) study was carried out with Australian registered diagnostic radiographers who were considered to have expert knowledge to gain a consensus on current best clinical practice for the optimal exposure and positioning of projectional radiographic imaging of the abdomen for obese patients. The e-Delphi technique has successfully been implemented in health sciences research, and at a preliminary level in diagnostic radiography, to allow researchers to gather opinions from experts and key stakeholders in the field and explore consensus on best practices [16]. The University of Sydney Human Research Ethics Committee approved both the use of interview transcripts from a previous study by Aweidah [17] as a base for our questionnaire and the online e-Delphi study that ran between May and June, 2017. The study comprised 2 stages: stage 1 was the generation of the concept map and stage 2 consisted of 2 rounds of e-Delphi methodology.

Stage 1: Thematic Analysis of Interview Transcripts—Questionnaire Development

A thematic reanalysis of interviews gathered from the previous, related study [17] was undertaken to inform the questionnaire in Delphi round 1 (stage 2). The original interviews, which used a grounded theory methodology, explored first, the attitudes and perceptions of Australian clinical educator diagnostic radiographers (CEDRs) towards obese patients, and second, common techniques and adaptations used by the CEDRs to improve image quality when imaging the abdomen of obese patients. The transcripts from the 12 semi-structured interviews were analysed and coded to determine prevalent themes in regards to adaptation of technique related to imaging the abdomen of obese patients as this was not previously analysed in the study by Aweidah [17]. A concept map (Figure 1) was then developed to visually display this analysis and to ascertain the main practice areas. The four main technical areas presenting key decision-making points by radiographers as identified from the transcripts were (1) exposure, (2) image acquisition techniques, (3) patient care, and (4) positioning.

Stage 2: Delphi Round 1—First Questionnaire

Eleven statements were developed in regards to the four key themes that were identified in the thematic analysis of interview transcripts (see Table 1). Once the statements had

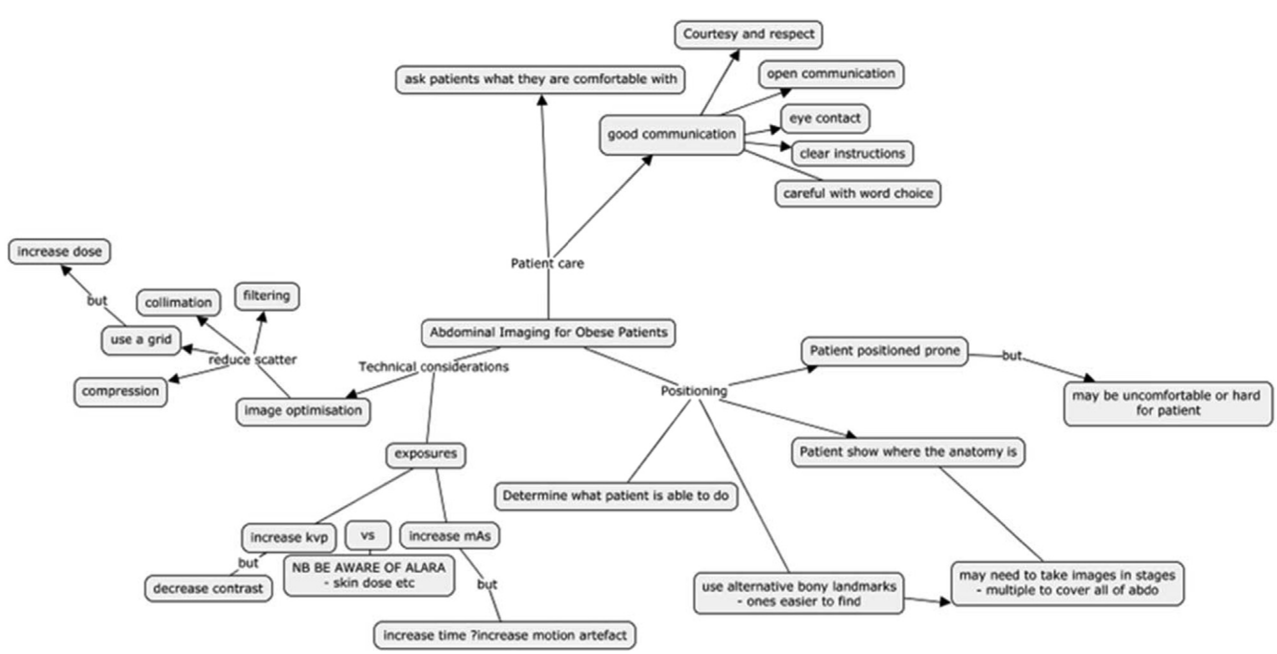

Figure 1. Concept map of radiographic adaptations. ALARA, As Low As Reasonably Achievable; kVp, peak kilovoltage; mAs, milliampere-seconds.

Table 1
Questionnaire Statements Here

Statement Round 1	Category	Phrased in Round 2
In order to compensate for patient density you have to increase the kVp	Exposure factors	Reached consensus in round 1
There is an optimal kVp for imaging the abdominal region, regardless of patient size	Exposure factors	Regardless of patient size, a kVp is found for the anatomy that provides the best contrast and is kept constant
When imaging the abdomen of obese patients the mAs should be increased rather than the kVp	Exposure factors	When imaging the abdomen of obese patients only the mAs should be manipulated to alter the exposure
It is easier to palpate the greater trochanter than the iliac crests on obese patients	Patient positioning	Palpating the greater trochanter rather than the iliac crests on obese patients is more suitable for positioning
Accurate positioning for AXRs on obese patients can be accomplished by using the greater trochanters as a landmark	Patient positioning	Using the greater trochanters as a landmark provides accurate positioning for an AXR
Accurate positioning can be achieved by asking the patient to locate their own surface anatomy landmarks	Patient positioning	Greater accuracy in positioning is achieved when patients locate their own landmarks
Prone positioning is preferable when imaging the abdomen of obese patients in order to reduce scatter	Patient positioning	Reached consensus in round 1
Taking pictures of the abdominal quadrants is the best way to image the entire abdomen of an obese patient	Image acquisition	Imaging the entire abdomen of an obese patient is best achieved by taking pictures of the abdomen in quadrants
Collimating to the cassette and not the patient is important when imaging obese patients	Image acquisition	Reached consensus in round 1
Raising the SID from 100 cm to 120 cm is essential in reducing the skin dose to the patient	Image acquisition	Reached consensus in round 1
Communicating the position required for an abdominal x-ray on an obese patient requires different language choices to other patients	Communication	Radiographers are required to use different language choices for obese patients when communicating the position required for an abdominal x-ray

AXR, abdominal x-ray; kVp, peak kilovoltage; mAs, milliampere-seconds; SID, source-to-image distance.

been finalised, an online survey using SurveyMonkey as the host server was disseminated via email. Although classical Delphi technique relates to face-to-face panels, direct interaction between participants was not suitable for this study as many potential participants work in regional or remote settings. The statements were presented as a 6-point Likert scale to quantify strength of agreement. Before the survey being released, a consensus threshold was set at greater than 75% of participants being in agreement through a positive or negative response to the statement. Although some debates do exist about the absolute threshold for consensus, 75% was chosen in line with other similar published work in the field of medical radiation sciences [16].

CEDRs from NSW public hospitals were purposively sampled from a database held by the University of Sydney and were invited to take part in the online survey via an email. These radiographers were considered to be experts as they had all been practising for a minimum of 5 years in their position as a clinical educator in the NSW Health system. Clinical educators who could not be reached via email, or who were known to be in the position of clinical educator for less than five years, were excluded from the sample. A total of 35 CEDRs were invited to be part of the study. After a month, to increase participation rates, a second email with the link to the survey was sent out as a reminder. After 6 weeks, 15 CEDRs had completed the questionnaire and the portal was closed. The results of the survey were analysed using descriptive statistics, with the threshold for consensus established at 75% strong positive or negative agreement (completely agree, strongly agree, strongly disagree, or completely disagree).

Stage 2: Delphi Round 2—Second Questionnaire

Of the initial 11 statements, seven did not reach consensus by the CEDRs. Therefore, these statements were rephrased in an attempt to provide greater clarity by contracting the Likert scale to 5 choices to allow for a neutral response and removing more subtle "generally agree; generally disagree" options. To gain greater insight into the possible spread of results, a free-text comments section was also developed for each statement so that the expert radiographers could justify their answers if they wished to do so. This was deemed important as it may inform why perhaps no consensus was reached. In continuing with the e-Delphi methodology, the online survey was again distributed to the same 35 CEDRs and the results of Delphi round 1 were included to allow participants access to filtered feedback about the group results of round 1. Fourteen responses were received and the same 75% threshold for consensus was applied. The comments supplied for each statement in round 2 were thematically analysed for frequency and provided insight into why specific answers had been chosen and to help inform the reasons related to some areas of practice where a consensus was still unable to be reached.

Results

Stage 1: Thematic Analysis of In-Depth Interviews

The three main areas of radiographic considerations identified from interview transcripts were "image acquisition" (including radiation exposure as a subtheme), "patient care," and "positioning". Within "image acquisition," a common challenge that radiographers identified in regards to imaging obese patients was controlling scatter radiation. In regards to the selection of "exposure factors," there were a variety of responses, which either advocated for an increase in exposure by utilising a greater kVp or conversely by increasing the mAs. This transcript evidence demonstrated that there was little clarity in the area of exposure technique among the 12 expert radiographers in the study by Aweidah [17]. The theme of "positioning" was identified as a difficulty many radiographers faced in palpating bony landmarks on obese patients. Some alternative landmarks and methods of identifying anatomy were suggested such as using greater trochanter palpation rather than the iliac crests and asking patients to help identify their own bony anatomy. Finally, "patient care" was a theme that radiographers identified when imaging obese patients. From the interviews it was evident that radiographers felt that communication with patients was an essential way to provide best patient care; however, there was some variance as some radiographers believed that they would adapt their language choices. This adaptation included being more sensitive in word choices to obese patients when describing the positioning involved, whereas others utilised the same communication techniques for all patients regardless of size.

Stage 2: Delphi Round 1 Results

In round 1 of the Delphi study, the expert group of 15 clinical educator radiographers from NSW public hospitals completed a survey of 11 statements. At the end of the round, the CEDRs had reached consensus in 4 of the 11 statements. These were statements relating to exposure and some aspects of positioning (see Table 2). Over 90% of respondents "strongly agreed" or "agreed" that to compensate for patient size, the kVp should be increased. Other techniques that reached consensus included validation of the technique of collimating the beam to the cassette or image receptor rather than the size of the patient to reduce scatter and increasing the source-to-image distance (SID) from 100 cm to 120 cm to reduce the skin dose to the patient and achieve greater receptor coverage. The use of prone positioning for a plain projection of the abdomen for obese patients was determined not to be best practice, with a consensus rate of 86% indicating "strongly disagree" for this statement.

Stage 2: Delphi Round 2 Results

The consensus threshold was maintained at 75% of participants with a positive or negative response to the statements. The CEDRs reached consensus on a further two statements and these related to the technique of exposure factors (see Table 3). Over 90% of the expert group disagreed that there is an optimal kVp range for the abdominal region regardless of the patient's size. Radiographers also strongly disagreed that when imaging the abdomen of obese patients, only the mAs should be manipulated to alter the exposure. At the end of round 2, the CEDRs were unable to reach consensus on five statements in determining the best practices when imaging obese patients. These statements were focused on positioning and communication techniques (see Table 3).

Table 2
Round 1 Responses

Statement	Theme Statement Targets	Mean (Standard Deviation)	Degree of Consensus	Achieved Consensus (Y/N)
In order to compensate for patient density you have to increase the kVp	Exposure factors	4.73 (0.96)	93% responses at 4 or above	Yes
There is an optimal kVp for imaging the abdominal region, regardless of patient size	Exposure factors	3.20 (1.61)	53% at 3 or below	No, round 2
When imaging the abdomen of obese patients the mAs should be increased rather than the kVp	Exposure factors	4.13 (1.25)	66% at 4 or above	No, round 2
It is easier to palpate the greater trochanter than the iliac crests on obese patients	Patient positioning	3.06 (1.62)	67% at 3 or below	No, round 2
Accurate positioning for AXRs on obese patients can be accomplished by using the greater trochanters as a landmark	Patient positioning	3.60 (1.72)	60% at 4 or above	No, round 2
Accurate positioning can be achieved by asking the patient to locate their own surface anatomy landmarks	Patient positioning	2.60 (1.42)	73% at 3 or below	No, round 2
Prone positioning is preferable when imaging the abdomen of obese patients in order to reduce scatter	Patient positioning	2.27 (1.22)	86% at 3 or below	Yes
Taking pictures of the abdominal quadrants is the best way to image the entire abdomen of an obese patient	Image acquisition	3.93 (1.58)	67% at 4 or above	No, round 2
Collimating to the cassette and not the patient is important when imaging obese patients	Image acquisition	5.27 (1.33)	93% at 4 or above	Yes
Raising the SID from 100 cm to 120 cm is essential in reducing the skin dose to the patient	Image acquisition	4.33 (1.30)	80% at 4 or above	Yes
Communicating the position required for an abdominal x-ray on an obese patient requires different language choices to other patients	Communication	3.27 (1.49)	53% at 3 or below	No, round 2

AXR, abdominal x-ray; kVp, peak kilovoltage; mAs, milliampere-seconds; SID, source-to-image distance.

Table 3
Round 2 Responses

Statement	Theme Statement Targets	Mean (Standard Deviation)	Degree of Consensus	Achieved Consensus (Y/N)
Regardless of patient size, a kVp is found for the anatomy that provides the best contrast and is kept constant	Exposure factors	1.71 (0.82)	92% responses at 2 or below	Yes
When imaging the abdomen of obese patients only the mAs should be manipulated to alter the exposure.	Exposure factors	2.07 (1.14)	85% at 2 or below	Yes
Palpating the greater trochanter rather than the iliac crests on obese patients is more suitable for positioning	Patient positioning	2.86 (1.03)	28% at 2 or below	No, thematic analysis of comments
Using the greater trochanters as a landmark provides accurate positioning for an AXR.	Patient positioning	3.07 (1.07)	42% at 4 or above	No, thematic analysis of comments
Greater accuracy in positioning is achieved when patients locate their own landmarks	Patient positioning	2.79 (0.97)	35% at 2 or below	No, thematic analysis of comments
Imaging the entire abdomen of an obese patient is best achieved by taking pictures of the abdomen in quadrants	Image acquisition	3.29 (0.91)	43% at 4 or above	No, thematic analysis of comments
Radiographers are required to use different language choices for obese patients when communicating the position required for an abdominal x-ray	Communication	2.86 (1.35)	50% at 2 or below	No, thematic analysis of comments

AXR, abdominal x-ray; kVp, peak kilovoltage; mAs, milliampere-seconds.

For the 5 statements where the CEDRs were not able to consensus by the end of round 2, a thematic analysis of the comments provided by the radiographers was undertaken. Although the numerical results relating to the undecided statements were predominantly neutral for these 5 statements, there were common themes present in the comments (see Table 4). A clear trend was that obese patients were presented in various stages of illnesses which makes a standardised method of positioning challenging. Furthermore, many of the expert radiographers commented on the need to utilise techniques which the radiographer can confidently apply, that is, those that they have practised with good results over a period. One concept that reached a clear consensus in the comments section of the survey (although not in quantitative results) was that the expert radiographers believed that the technique of asking patients to locate their own bony landmarks should not be used. The expert radiographers considered from their experiences that this was a highly inaccurate technique, with many patients not being able to distinguish where their own anatomy was located, or did not understand the requirements to do so.

Discussion

The results of this study have led to some interesting findings regarding the current practices and beliefs of expert Australian radiographers when optimising imaging practices for obese patients. Techniques related to the empirical aspects of radiography such as exposures, collimation, and SID adaptations generally reached consensus after 2 rounds. This is perhaps because they are scalar in nature and have a mathematical relationship to patient size, measures of image quality such as noise, and can be quantified in terms of distance, kVp and mAs. For example, the method of adaptation for obese patients in utilising an SID of 120 cm to reduce dose and collimation to the cassette/image receptor rather than the patient was considered best practice by the CEDRs. The reference group in this study concurred with past studies [10,17] that good practice can be achieved in relation to reducing dose by increasing the SID. The aspects of radiography that can be considered more humanistic, for example, tactile positioning and communication with the patient, had more varied responses and did not fit a method of numerical consensus.

Past literature regarding imaging obese patients has identified exposure factors as a key technique that needs to be adapted. However, there has been a lack of evidence-based literature to suggest how to do this with accuracy [1]. The expert radiographers in this study agreed strongly that the kVp needs to be increased to compensate for patient size, and similarly they agreed that the mAs should also be increased. These results suggest a preference for a combined approach in regards to increasing the exposure when imaging obese patients. However, despite the statements on exposure factors reaching a consensus, this study was not designed to

Table 4
Thematic Analysis

Question	Question Category	Main Themes	Quotes
3	Positioning	• Patient size • Radiographer confidence • Radiographer experience	"Totally dependent on patient shape/muscle tone/weight distribution"
4	Positioning	• Radiographer confidence	"Depends on radiographer preference and confidence of one technique over the other."
5	Positioning	• Patient's are not able to accurately locate their landmarks	"Often obese patients do not know where certain landmarks are, giving false pointers"
6	Image acquisition	• Patient size • Important anatomy	"generally we over image obese…There is a drive to image all the tissue laterally… which is not required"
7	Communication	• Respect	"all [patients] require sensitive communication that is respectful and non-shaming"

quantify the extent to which kVp and mAs should be altered in relation to patient size and this represents a key area for future research. In addition, the questionnaire can be expanded by including specific questions related to exposure techniques such as the use of automatic exposure control, consideration of exposure indices, and the influence of digital radiography (DR) after processing. Surprisingly, the aforementioned techniques were not raised by the CEDRs in the free-response sections to the round 2 Delphi questionnaire; however, this was a limited opportunity to provide information related to a statement rather than elicit rich text data. Overall, the aims of the statements in this Delphi study were to determine broad optimisation techniques regardless of access to different equipment and vendors.

Respect for patients regardless of their size and the uniqueness of patient presentation were important considerations that emerged from the comments section in round 2, and these themes were similar to those expressed by radiographers and radiologists in the Aweidah [17] and Destounis [9] studies, respectively. The qualitative responses by the CEDRs expanded the concept that obesity is not like other pathologies or health conditions, where patients can be categorised into discrete groups related to technical adaptation, such as specific bone diseases or trauma. Instead, in regards to imaging, the participants appeared to consider that BMI does not define the clinical scenario but rather manifested in a variety of different patient presentations, sizes, illnesses, and levels of mobility.

The themes from the open-ended responses indicated that expert radiographers relied on their own personal experience to confidently adapt their technique rather than a standard procedure of optimisation; however, exact details on which techniques they used did not emerge. As an example, some radiographers said they would use the top of the iliac crest, whereas others may find it easier to use the greater trochanter as a landmark for positioning. Some techniques were definitely considered to be unsuitable practice by the CEDRs, such as using prone positioning of the patient for an abdominal radiograph and using the patient to help identify landmarks. This result is in contrast to common radiographic textbooks such as that of Bontrager [18], who list prone positioning as an alternative to supine for imaging the abdomen. Research that addresses the lack of clarity around specific positioning techniques needs to be explored as this will likely have a significant impact on education of student radiographers by CEDRs.

Although this study provides rich data on methods of best practice in abdominal imaging of obese patients by an expert radiography group, there are some limitations. When completing the survey, no demographic questions were included. It was considered that each participant was highly experienced as the database of DR clinical educators in NSW Health was purposively sampled to include those radiographers who had held this position for at least 5 years meaning that they had at least 8 years of experience on average after graduation, many with upwards of 20 years and beyond experience. However, without explicitly recording years of experience, it was not possible to know exactly how experienced each radiographer was. The variation in years of experience for the expert radiographers means that it is possible responses to the exposure technique statements are a result of the radiographers' personal radiographic education in either film screen systems, computed radiography or DR technologies. Hence, responses to statements about radiographic exposure may be influenced by past education and work practices as there was a significant change in technologies around the turn of the millennium.

As participants were not asked to provide a unique identifier, it is also not possible to be certain that the respondents in round 1 and round 2 were the same sample; however, it is highly likely that many were dual responders. Furthermore, information on the frequency in which the CEDRs encountered situations where they have had to image obese patients was not recorded. The study aimed to limit this risk of lack of personal experience by utilising public hospital's clinical educators, as they are more likely to encounter obese patients through acute clinical settings. It is possible that some expert radiographers in this study were also interviewed in the study by Aweidah [17], meaning that their responses may have influenced both the development of the questionnaire and the Delphi consensus data.

Another challenge to the study design was gaining a significant number of responses to the survey. A study by de Villiers et al [19] showed that for Delphi studies, a panel generally consists of 15–30 experts and that increasing the group passed 30 does not improve results. After 6 weeks, and one reminder email, there were 15 responses in round 1 and 14 in round 2. While this is on the lower end of the spectrum, the responders are considered experts in their field and thus this sample is representative of the small target population of Australian CEDRs.

Owing to the limited time frame, only two rounds of the e-Delphi study were undertaken, which meant that a consensus was not reached on all of the statements, although the richness of the experts' comments enabled some clear themes and trends to be attained. The pilot nature of this study means that the areas that were not resolved can be explored in further research and the flexibility of Delphi methodology could extend future work to multiple rounds or face-to-face consensus and collaboration [16]. The Delphi questionnaire was grounded in themes derived from transcript evidence; however, it was not an exhaustive list of statements related to imaging obese patients.

Part of the design of the study was that the survey in round 2 was modified from a 6-point Likert scale to a 5 point one. This was carried out to reduce the spread of results but also to allow for a neutral option. This resulted in some of the statements in round 2 not reaching a consensus as the neutral option was favoured. However, this lack of consensus was informed by insightful comments obtained from the experts' responses in the comment section when they did select a neutral response. The comments combined with the numerical consensus indicate that in many regards, optimisation is an under-researched field and radiographers often rely on historical education or confidence in an attempt to provide good practice.

Conclusion

This study reports that CEDRs considered it hard to categorise obese patients into a discrete group as there is much variation in patient presentation and obesity is multifactorial. Personal experience and confidence were considered essential in adapting technique. Broad consensus was reached on some technical aspects of projectional radiography, such as collimation, and manipulation of SID, kVp, and mAs. However, within this consensus, our results suggest there are still inconsistencies in clinical practice where further research could help guide practice. With obesity continuing to increase in prevalence, there is an identified gap in knowledge by radiographers and clinical educator, indicating further study is required.

Footnotes

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