BJR https://doi.org/10.1259/bjr.20190632

Received: 15 July 2019 | Revised: 05 February 2020 | Accepted: 25 February 2020

Cite this article as:
Rohringer TJ, Rosen TE, Lee MR, Sagar P, Murphy KJ. Can diagnostic imaging help improve elder abuse detection?. *Br J Radiol* 2020; **93**: 20190632.

REVIEW ARTICLE

Can diagnostic imaging help improve elder abuse detection?

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ABSTRACT

Elder abuse is an underdetected, under-reported issue with severe consequences. Its detection presents unique challenges based on characteristics of this vulnerable population, including cognitive impairment, age-related deconditioning, and an increased number of co-morbidities, all of which predispose to increase vulnerability to injury. While radiologists play a critical role in detection of child abuse, this role is currently not paralleled in detection of elder abuse. We conducted a thorough review of the literature using MEDLINE to describe the current knowledge on injury patterns and injury findings seen in elder abuse, as well as barriers to and recommendations for an increased role of diagnostic imaging in elder abuse detection. Barriers limiting the role of radiologists include lack of training and paucity of rigorous systematic research delineating distinctive imaging findings for physical elder abuse. We outline the current ways in which imaging can help raise clinical suspicion for elder abuse, including inconsistencies between purported mechanism of injury and imaging findings, injury location, multiple injuries at differing stages of healing, and particular patterns of injury likely to be intentionally inflicted. We additionally outline the mechanism by which medical education and clinical workflow may be modified to increase the role for imaging and radiologist participation in detecting abuse in older adult patients, and identify potential future directions for further systematic research.

INTRODUCTION

Elder abuse has been broadly defined as behaviors or negligence against an older adult that results in harm or the risk of harm committed by someone in a relationship with an expectation of trust or when the victim is targeted because of age or disability.[1] Elder abuse has been widely recognized to consist of five main subtypes: physical (behaviors intended to cause the victim physical pain or injury), verbal/psychological (behaviors intended to cause the victim psychological pain or injury), sexual (non-consensual touching of a sexual nature), financial exploitation (misuse/misappropriation of victim's property or money), and neglect (failure of a caregiver to adequately care for a dependent victim).[1,2] Prevalence of elder abuse is challenging to characterize due to underdetection and under-reporting, but has been estimated to occur in approximately 10% of community-dwelling older adults.[2,3] This prevalence may be much higher than 10% when examining older adults living in institutional environments.[4–7] Of the older adults that present to the emergency department, prevalence of elder abuse has been reported to range between 2.2 and 18.4%, depending on the country.[8] A recent study examined presenting complaints among cognitively intact older adults to the emergency department, and reported a history of psychological mistreatment or physical abuse in 7%. This statistic is likely an underestimate of the prevalence of abuse in older adults presenting to the emergency department, as it doesn't include other forms of abuse such as financial abuse and neglect, and further does not examine cognitively impaired older adults, amongst whom abuse occurs more commonly.[9,10] As the population ages and advances in healthcare allow for longer lifespans, abuse of older adults is expected to become more common.[2,8,11] Moreover, abuse in older adults is associated with worsened quality of life, health outcomes and survival.[1,2,11] Older adults who have been the victim of abuse have a higher mortality rate

compared to other older adults, and have been reported to have a higher incidence of chronic conditions such as depression and dementia. Victims of elder abuse are additionally more likely to present to hospital, be admitted to hospital, and be put in a nursing home.[12] The concept of elder abuse was only described in the literature during the 1970s, much after the characterization of child abuse and intimate partner violence.[13] The radiological appearance was first described by Murphy et al in 2013.[14] This speaks to the deficit and significant knowledge gap that exists in healthcare around identifying and reporting elder abuse.

It has been estimated that fewer than 1 in 24 elder abuse cases are detected and reported.[3] One important reason for the under-reporting of elder abuse is a lack of disclosure by victims. When seeking healthcare, many victims report unintentional trauma in cases of physical abuse.[15] Reasons for lack of disclosure may include cognitive or sensory impairment that precludes the ability to disclose, fear of isolation from a caregiver, personal or familial shame or embarrassment, fear of reprisal, stoicism, unwillingness to implicate a friend or family member, and fear of being perceived as ungrateful.[8,16] The frequent lack of explicit disclosure emphasizes the importance of understanding and investigating the risk factors for elder abuse. These risk factors include a familial culture of violence, social isolation, dementia, depression, debilitation/dependence on caregiver, shared living arrangements, financial stress or other life stressors, and an abuser with mental health issues, substance abuse issues, or dependence on the victim.[14,16] Physicians must have a high index of suspicion for abuse and explore aforementioned potential red flags when they arise in order to improve detection and action surrounding older adult abuse.

For multiple older adults, their only contact outside of their caregiving environment is their healthcare practitioner.[17] This bestows a responsibility on healthcare providers to recognize and report suspected elder abuse. Mandatory reporting obligations have recognized such onus, and most states in the United States have mandatory reporting obligations for physicians with respect to elder abuse in all settings, and Canada has mandatory reporting obligations for physicians with respect to elder abuse occurring in long-term care homes.[16] Despite this, physicians infrequently report elder abuse, with estimates that physicians contribute to a mere 2% of reported elder abuse cases in the United States.[1,16,17] Barriers to physician reporting have been reported to be multifold, including ageism, lack of training in geriatric health, lack of systematic screening practices, lack of knowledge of reporting mandates, fear of straining the patient–physician relationship, time limitations, and uncertainty of diagnostic validity.[1,11,16,18]

This review will focus primarily on physical elder abuse, as physical trauma is a common reason to seek healthcare in older adults—injurious falls (purportedly unintentional injury) is one of the most common reasons for older adults to present to the emergency department. In the setting of the common presentation of purported unintentional trauma, such as fall, to the emergency department, healthcare providers would ideally be able to delineate those cases that are in fact intentional abuse cases.[18] Characterizing physical abuse in the elderly presents a distinct problem from that of physical abuse in children. Injury patterns with high sensitivity and specificity for child abuse have been well-characterized, such as posterior rib fractures, metaphyseal corner fractures and depressed skull fractures.[19] Age-related changes and increased co-morbidities in older adults have rendered delineating similarly pathognomonic injury patterns more challenging in the geriatric population, *e.g.* osteoporosis and use of medications such as anticoagulants.[19] Radiologists play a critical and central role in detection of child abuse, and may be able to play a similarly crucial role in detection of elder abuse. Lack of clear characterization taken with poor disclosure by victims and poor recognition by physicians elucidates the significant need for more objective and systematic detection of physical elder abuse, particularly at present as our population ages and the number of cases continue to increase. With elderly patients accounting for up to 24% of emergency department visits, and most patients undergoing imaging studies during these visits, the potential for diagnostic imaging to provide needed objectivity and support in detecting physical elder abuse is great.[19] The goal of the current study was to conduct a rigorous review of the literature to describe the current knowledge on injury patterns and injury findings seen in elder abuse, as well as barriers to and recommendations for an increased role of diagnostic imaging in elder abuse detection.

Search strategy

In order to identify injury findings specific to elder abuse and information about the radiologist's current role in detection, a comprehensive search of the MEDLINE database was performed. Search keywords included "radiological findings" or "radiographic findings" or "imaging" or "imaging findings" or "diagnostic imaging" or "medical imaging" or "CT" or "MRI" or "X-ray" and "elder abuse." Relevant English-language articles from between 1995 and 2019 were included. The reference lists of the selected articles were also explored, and further articles were included from them if they were deemed relevant to the clinical or imaging characterization of elder abuse.

Characterizing injuries in physical elder abuse

It is integral in our investigation into the role of imaging in detecting physical elder abuse to describe the typical injuries observed in victims, and we will discuss the existing literature that describes common injury patterns in physical abuse of older adults. The most common mechanisms of injury reported in physical elder abuse are beating with fists or other physical assaults, and striking with a variety of different household objects.[15] In a literature review by Murphy et al. in 2013 that investigated 839 reported physical injuries in elder abuse patents, the majority of injuries were to the upper extremities (43.98%), followed by the maxillofacial, dental and neck region (22.88%), the skull and brain (12.28%), the lower extremities (10.61%) and the torso (10.25%).[14] In another study of emergency department presentations of elder abuse victims for physical injuries, abuse-related injuries were most common on upper extremities (45%), followed by head and neck injuries (42%), and lower extremities (32%).[15] Another retrospective study found the most frequently injured areas in physical elder abuse to be the head and neck, followed by chest, breasts and abdomen.[8] With respect to the

types of injuries sustained, one study reported open wounds in 56.1% of cases, internal injuries in 24.4% of cases and fractures in 22% of cases.[20] Of the internal injury cases examined, 73.7% involved the pelvis, bladder and ureter.[20] Potential falls-related injuries that have a higher association with abuse are bruises on the breast, internal injuries, and upper extremity dislocations.[15,20] Case reports of specific injuries seen in elder abuse victims have included anterior sternal dislocations, ectopia lentis and depressed skull fractures.[21–23]

Though common locations and types of injuries sustained in physical abuse of older adults have been described, identifying these as being intentional amongst the large group of older adults presenting with purportedly non-intentional injuries is an additional challenge. In comparison to non-intentional trauma, abuse victims have been demonstrated to have a higher likelihood of injuries to their heads and torsos.[20] Additionally, visible bruising is commonly associated with elder abuse. One study indicated that 39% of emergency department visits involving physical elder abuse were associated with observed bruising, with the most common location being the upper extremities.[15] Another study reinforced this, illustrating that the location of bruises in geriatric victims of physical abuse was most commonly the lateral/anterior arms (34.3%), followed by the head and neck (14.9%) and the posterior torso (10.4%).[24] Further, the odds of observing lateral/anterior arm bruises were eight times greater when the victim reported a history of being grabbed, and the likelihood of observing head and neck bruises was significantly greater when the victim reported a history of choking and beating.[24] Another study found that victims of physical elder abuse are more likely to have posterior torso bruising and ulnar forearm bruising compared to elderly patients with unintentional injuries.[1] Preliminary results from ongoing research suggest that injuries to the neck and left face may be much more common in injuries sustained from abuse compared to non-intentional injuries like falls.[25]

Notably, existing literature also highlights many similarities between physical elder abuse injuries and those associated with intimate partner violence.[15,26] With this in mind, common injuries of fractures to the mid-face and left zygoma are frequently associated with domestic abuse and are not common in non-intentional injuries, which likely also applies to elder abuse.[15] Additionally, the lateral/anterior arm bruising as well as the head and neck bruising associated with physical elderly abuse is also commonly seen in victims of intimate partner violence.[24]

Tools have been developed to improve current practices surrounding investigation and documentation of physical elder abuse. The Geriatric Injury Documentation Tool (Geri-IDT) endeavors to use validated elements from standardized tools utilized for documentation of child abuse and intimate partner violence. This includes collecting historical information from both victim and caregivers/family separately, details specific to the mechanism of injury and a thorough description of physical exam findings with a body diagram as well as photographs when possible.[27] Insofar as the use of photographs for documentation in the setting of older adult abuse, a protocol has been developed for standardized photography of acute injuries by non-professional photographers that details optimal conditions for both photographer and subject to best capture injuries on various body regions, with associated instructional diagrams.[28]

Barriers to employing diagnostic imaging in detection

Characterization of injury patterns distinctive to intentional injury in older adults may be much more challenging than child abuse. For example, in children, severe bony injuries resulting from high energy injuries that are likely to solely be caused by high energy mechanisms such as beating very seldom occur from low energy mechanisms such as low-level falls. With age-related changes (such as deconditioning and balance impairment) as well as age-associated co-morbidities (such as osteopenia/osteoporosis) older adult patients may suffer severe bony injuries from low energy mechanisms, such as low-level falls.[19] Other geriatric conditions that increase patient vulnerability to fractures include malnutrition, vitamin D deficiency, and immobility/prolonged bed rest.[29] Geriatric patients are also commonly on one or more chronic medications that may increase their bleeding and fracture risk.[17] As a result, identifying injury/imaging patterns that are highly specific for physical elder abuse is challenging. Another important difference between child and older adult abuse in image analysis and abuse detection from the perspective of radiologists is the inability to infer functional status from age. In children, developmental milestones and functional status correlate highly with age, and thus radiologists may deduce whether a particular injury pattern fits the purported mechanism for a given child. In contrast, functional status can vary widely for older adults of a given age, thereby necessitating clinical information beyond patient age be given to the radiologist in order to understand the older adult patient's functional status and the context and feasibility of their injury (*i.e.* cognitive status, activity level, independence).[30] Further, the quality of imaging studies in the elderly population can frequently be limited due to poor quality of communication and thereby collaboration. Additionally, mobility limitations may limit not only the quality of study but the types of studies performed.

Older adults may be poor historians owing to cognitive, sensory or psychological impairment, or an unwillingness to disclose.[8,16] The subjectivity and uncertainty in abuse detection remains a major barrier to physician reporting, and the objectivity of imaging findings stands to significantly supplement the diagnostic process, thereby improving detection and reporting. Rigorous research studies may identify clinically useful differences in imaging between physical elder abuse and unintentional injuries. In fact, extensive literature exists describing these differences in child abuse.[31–36] Unfortunately, we did not find any large comparative studies examining potential imaging differences between physical elder abuse and unintentional injury. As a result, it is difficult for radiologists and clinicians consider physical elder abuse when examining imaging. It was this lack of evidence-based pathognomonic findings that has been cited as a central reason that radiologists, who play a crucial role in child abuse identification, very seldom contribute to elder abuse detection.[29] Another important barrier is a lack of communication

between the clinical team and the radiologist. In fact, qualitative research suggested that event experienced radiologists reported never being asked by a clinician to assess images for potential elder abuse.[30] Further, radiologists assessing images often do not have access to information about physical exam or clinical history, including the mechanism of injury and functional status, which limits their ability to interpret.[1,19,29,30] Research suggested that very few radiologists report receiving any training, formal or informal, on radiologic features of elder abuse, an important barriers.[30] Radiologists are beginning to recognize the importance of these barriers. In qualitative research, all radiologists interviewed reported believing that they had missed cases of elder abuse on imaging.[30]

Imaging findings in physical elder abuse

Though further research is required to determine evidence-based imaging correlates for physical elder abuse, there is limited existing qualitative and case report literature that has suggested potential imaging findings that may suggest physical elder abuse. One way that imaging can assist in elder abuse detection is assessing whether the imaged injuries are consistent with the purported mechanism of injury taken on history.[3,16,30] Inconsistencies between the reported history and injury pattern found on imaging should raise suspicions for abuse. One important example is if a low energy mechanism is reported, but a high energy injury is observed on imaging.[3]

Another finding that existing literature suggests should raise suspicion is multiple injuries at various stages of healing, indicating repetitive trauma over time.[3,30] Multiple healed fractures, especially if they are misaligned, should heighten suspicion for abuse—particularly in the absence of an alternate clinical explanation (such as severe osteoporosis with multiple fragility fractures).[16]

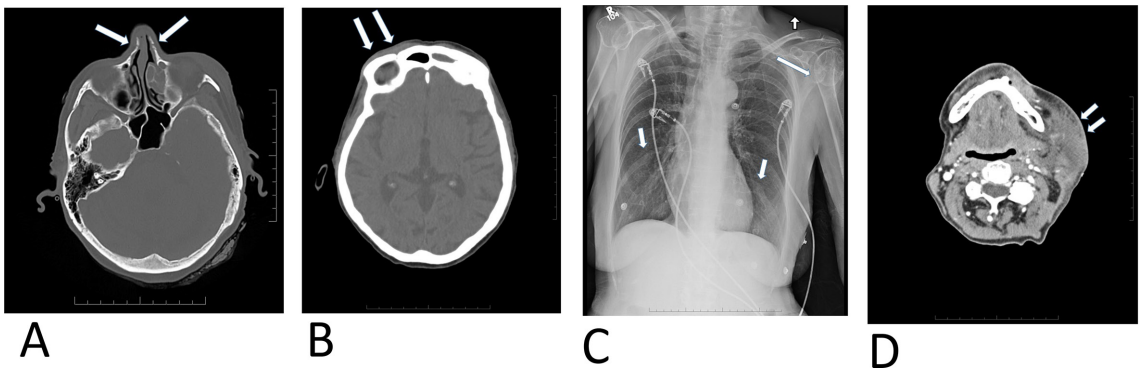
Injuries in particular locations, such as the upper extremities and maxillofacial region, should also increase suspicion for abuse, taken with the rest of the clinical context.[3] Certain combinations of clinically visible injuries with injuries visualized on diagnostic imaging may also be suggestive of abuse, including bruising on the posterior torso in association with posterior rib fractures, and bruising on the ulnar forearm in association with distal ulnar diaphysis fractures.[1]

Injuries that are unlikely to be caused by non-intentional trauma may also be suggestive of abuse.[3] For example, when a fall occurs onto an outstretched hand, resultant injuries to the wrist are common—however, fractures to the distal radial metaphysis are much more common than those to the distal ulnar diaphysis, and the latter should increase suspicion for abuse (a potential self-defence injury).[1,3] Additionally, injury patterns characteristic of intimate partner violence or domestic abuse may suggest abuse in an older adult, including mid-face and zygomatic fractures.[15] Anterior sternoclavicular dislocations that are often caused by posterior shoulder rotation from an indirect force are unlikely to be caused by non-intentional trauma, and should alert the radiologist and clinician to potential abuse.[23] In a case with no clinical suspicion of abuse based on history, elder abuse was able to be identified based on this imaging finding.[23] All high-energy injuries, such as upper rib fractures, should be emphasized as potential indicators of abuse on imaging.[30]

In order to demonstrate these findings, imaging from two illustrative patients who were victims of physical abuse have been included. The first is a 63-year-old patient who was punched in the face and chest, with resultant soft tissue injury, nasal bone fractures, and central cord syndrome secondary to neck hyperextension (Figure 1A–C). The second is a 70-year-old patient who had multiple presentations to hospitals and accumulated imaging over these various visits that demonstrated findings such as nasal

Figure 1. A 63-year-old female punched in the face and chest, complaining of chest pain and aphasia post-assault. (A) Non-contrast CT head axial slice demonstrates soft tissue swelling consistent with subcutaneous hematoma over the midline of the frontal bone (thin arrow). (B) Non-contrast CT head axial slice illustrating additional findings of acute minimally displaced nasal bone fractures (thick arrow). (C) Sagittal section of cervical spine MRI to rule out traumatic dissection of the carotid artery demonstrates abnormal cord signal from C4 to C6 (arrows) consistent with cord edema *vs* central cord contusion. Follow-up imaging 10 days later demonstrated complete resolution of cord edema. This likely represents central cord syndrome. A chest CT/CTA to rule out traumatic aortic dissection was unremarkable in this patient.

Figure 2. A 70-year-old female who presents following a punch to the face with bruising around her right orbit. This patient has a history of multiple admissions to the emergency department at multiple institutions. (A) An axial slice of a non-contrast CT of the head demonstrates soft tissue swelling over the left orbit, fracture of the medial wall of the left orbit, and comminuted nasal bone fractures (arrows). (B) Axial slice from the non-contrast CT head shows a soft tissue hematoma over the right frontal bone (arrows). (C) A chest X-ray from the same visit shows bilateral healed rib fractures (short arrows) and left humeral neck fracture (long arrow). (D) This patient represented to hospital 3 months later with repeat trauma, with a non-contrast CT of the head demonstrating an extensive subcutaneous hematoma over the left side of the neck on the axial view (arrows). There is asymmetric left mandibular and parotid soft tissue swelling.



bone trauma, multiple rib fractures at different stages of healing, and orbital swelling (Figure 2A–D).

Notably, diagnostic imaging may also have a role in the detection of other types of elder abuse including neglect.[37] Findings including bedsores, cachexia and fecal impaction may suggest neglect, particularly if not present on previous imaging.[10]

Potential changes to increase the role of diagnostic imaging

Based on existing literature, concrete steps may be taken to increase the role of diagnostic imaging in elder abuse detection. A powerful way to increase the utility of diagnostic imaging in the detection of elder abuse is to increase the amount of clinical information communicated to the radiologist, with the systematic incorporation of certain clinical features..[1,29] The purported mechanism of injury should be included (and whether any conflicting stories about this mechanism of injury were gathered from different parties in the clinical setting) so that the radiologist may incorporate this into their assessment of images and recognize a mechanism mismatch suggestive of potential abuse.[29] Also, an older adult's functional or ambulatory status should be communicated to the radiologist so that they may be incorporated into imaging interpretation. This is analogous to the use of developmental milestones in interpretation of images in children when considering child abuse.[29] A potential objective measure of functional status, such as a clinical frailty scale, may be useful.[38] A potential objective measure of this could be the clinical frailty scale. Relevant medications (*e.g.* anticoagulants that alter bleeding risk or glucocorticoids that alter fracture risk), as well as relevant co-morbidities (*e.g.* osteoporosis, which increases fracture risk), should also be communicated to the radiologist. Conversely, the radiologist should also exercise additional attention to detail in what clinical history is available to them for elderly patients with traumatic injuries.

Additionally, the information that we do know should be incorporated into medical education for both clinicians and radiologists, such that both groups may better appreciate the utility of diagnostic imaging in supporting the detection of physical elder abuse and what findings may be suggestive.[18,19,29] Radiologists should be educated on the more common locations and types of injuries associated with intentional trauma that were detailed previously, so as to include in their report and thereby alert clinicians that they may be associated with elder abuse.[3]

Both the clinical team and the radiologist should be empowered to contact each other with any concern for elder abuse. Clinicians should report findings from their observation of the patient and caregiver,[16] the medical history,[16] and physical exam.[17] Additionally, clinicians may utilize screening tools universally in the older adult population to help identify potential victims. Currently available tools exist such as the Elder Abuse Suspicion Index[39] and the ED Senior AID.[40] Additionally, visible injuries that may be associated with abuse, such as lateral/anterior arm bruises, should be reported to the radiologist in a standardized way—such as by using a systematic approach to photography and the Geri-IDT tool discussed previously.[27,28]

Cases have been reported where, despite no indication or suspicion of abuse, elder abuse has been detected through imaging findings.[23] Radiologists and clinicians have also worked together reduce the concern for abuse. Further imaging studies may be of use in cases of clinically or radiographically suspected abuse in older adults. A skeletal survey, which involves X-rays of the entire body, and neuroimaging is routinely conducted on young children in whom child abuse is suspected to identify old or occult injuries. An analogous approach with targeted images (X-rays of forearms chest and CT maxillofacial and head) may be appropriate for older adult patients who are suspected to be abuse victims, particularly in patients who are cognitively impaired. Existing literature suggests that a multidisciplinary

team-based approach is critical to optimize elder abuse detection.[10]

Potential future opportunities

Through conducting this review and outlining the results, areas for further work have emerged that we will outline here. First, the clear need for large-scale imaging studies, which are required to validate imaging correlates for physical elder abuse.[3] These include large case series and comparative studies. This would allow for evidence-based findings on various types of imaging modalities that could be taught to radiologists and the broader healthcare team as being suspicious for abuse.

A possible additional source for imaging correlates in older adult abuse is post-mortem/forensic imaging. While a large percentage of children who die receive complete autopsies for determination of cause of death, this is much less common for older adults.[41] Full body post-mortem CT imaging is much less expensive and resource-intensive than such extensive imaging antemortem.[42,43] It's utility in child abuse is under study, and preliminary work has been done on the utility in elder abuse, which has the potential to identify reliable imaging correlates for abuse in this population.[43]

Through development of advanced data analytics techniques such as machine learning, artificial intelligence has the potential to dramatically improve elder abuse identification in healthcare. It can help detect subtle differences between unintentional and intentional injuries on imaging in older adults that are hard to discern for the human radiologist, which require large-scale studies to generate accurate cases and controls to be used as use-cases.[44] There is also potential to analyze the patterns of patient presentation to the healthcare system in association with patient medical imaging so that we may have an algorithm to help identify older adult abuse victims.

The role of imaging may extend beyond detection in elder abuse, to screening for those at increased risk for abuse. A case–control study using MRI findings of financially exploited older adults demonstrated cortical thinning in the anterior insula and posterior superior temporal cortices—areas involved in processing emotional and social information. Within-network functional connectivity in the default and salience networks was decreased in exploited patients, while between-network functional connectivity was increased.[37] This study demonstrates the potential for imaging findings to illustrate increased vulnerability of older adults to a variety of abuse types.

Oftentimes, in situations of abuse in which the perpetrator accompanies the victim to the emergency department, perpetrators are unwilling to leave the patient alone with healthcare providers, rendering it difficult for victims to ask for help or report abuse. The importance of getting history from both the patient and anyone accompanying the patient, separately, is underlined in the Geri-IDT tool. As imaging plays an increasing role in the care of potential elder abuse victims, the potential for the radiology technician to assess and screen for abuse has been investigated. Radiology technicians are in a unique position as they are able to spend time alone with the patient.[45,46] Patients may also feel more comfortable disclosing these sensitive matters to the radiology technicians due to fewer perceived consequences compared to disclosing to a physician.[45,46] Thus, another future area of opportunity is training not only of radiologists on screening and detection of elder abuse, but also of radiology technicians.

CONCLUSION

Diagnostic imaging represents a potentially valuable but underutilized tool to improve accurate identification of abuse in older adults. Limited information about injuries specific for physical elder abuse have been described, but potential patterns are already emerging. Increased research focused on describing injury patterns, improved communication between clinicians and radiologists, a multidisciplinary approach, and additional education are critical to improve radiologists' contribution to elder abuse detection. Future approaches that may further increase the potential of imaging in elder abuse identification include accrual of post-mortem CT imaging, use of machine learning for pattern recognition and improved detection, using neuroimaging to identify vulnerability to abuse, and screening by technologists in the radiology suite.

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