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Case Report

Evaluating silicone breast implant rupture with photon-counting CT and volumetric silicone maps ☆

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ARTICLE INFO

Article history:
Received 7 March 2024
Revised 2 May 2024
Accepted 3 May 2024

Keywords:
Photon-counting CT
Silicone breast implants
Emergency department
Extracapsular rupture
Lymphadenopathy
Extracorporeal extrusion

ABSTRACT

We present a case of an 81-year-old woman who presented to the emergency department with bleeding from a right breast wound. The patient had prior imaging suggestive of bilateral silicone implant rupture and a history of low tolerance for MRI scans. Ultrasound imaging in the emergency setting showed findings in the right breast suggestive of a fistula with free silicone and hematoma. A subsequent photon-counting CT scan with custom silicone-specific segmentation allowed differentiation of silicone from hematoma, provided anatomic assessment and location of the fistula, and revealed bilateral silicone-induced lymphadenopathy.

Introduction

Silicone-specific MRI sequences are considered the gold standard for evaluating breast implant rupture, free silicone, and silicone-laden lymph nodes [1,2]. However, a significant portion of breast implant patients have contraindications to MRI or are simply unable to tolerate MRI examinations [3]. Ultrasound is an imaging alternative to MRI for breast implant evaluation, but ultrasound has lower sensitivity, lacks silicone-specific information, is susceptible to shadowing artifacts caused by implant calcification and rupture, and is highly operator-dependent [1]. Further complicating these matters is the recently revised FDA recommendation that all silicone implant patients be routinely screened every 2 to 5 years for implant evaluation [4,5].

To help meet this clinical need, dual-energy CT has been proposed as an imaging alternative for silicone implant patients with contraindications to MRI [6-9]. Similar to MRI, dual-energy CT can offer volumetric silicone-specific segmentation (i.e., silicone maps). In this case report we show that these prior dual-energy CT methods for silicone implant imaging

☆ Competing Interests: Andres Abadia, and Kristina A. Hallam, are employees of Siemens Heathcare. The remaining authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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https://doi.org/10.1016/j.radcr.2024.05.016

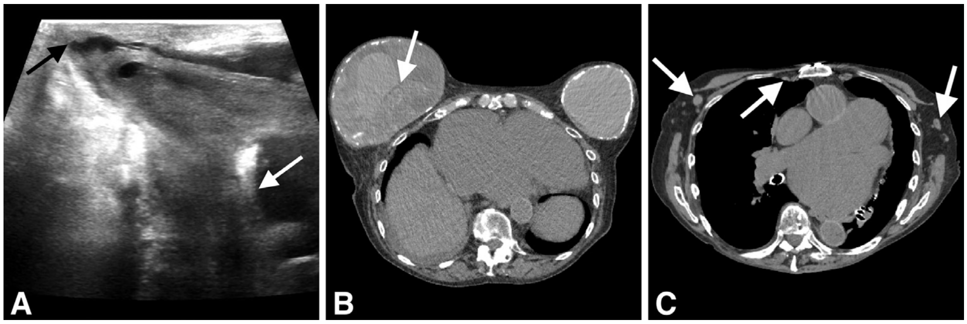

Fig. 1 – (A) 2D ultrasound image of the right breast showing a probable fistula (black arrow) and a heterogeneous echogenic appearance (i.e., snowstorm sign) from free silicone droplets mixed with breast tissue (white arrow). (B) 70-keV monoenergetic photon-counting CT showing amorphous heterogenous appearing areas in the right breast (arrow). (C) 70-keV monoenergetic photon-counting CT showing hyperattenuating, enlarged axillary and internal mammary lymph nodes (arrows). All CT image window level/width = 40/400 HU.

can be translated to first-generation clinical photon-counting CT systems with improved diagnostic features. These new features include the removal of dual-energy CT field of view limitations as a result of photon-counting CT improvements, and the differentiation of silicone from calcium as a result of our new method improvements that can be translated to all spectral CT systems.

Case report

An 81-year-old woman with a history of a stroke and a mitral valve replacement presented to the emergency department with bleeding from a right breast wound. Further history included silicone breast implants with CT-confirmed bilateral extracapsular rupture, asymmetric swelling and discoloration of the right breast, and a low tolerance for MRI scans. Ultrasound imaging of the right breast in the emergency setting demonstrated a probable fistula with areas of hemorrhage and free silicone (Fig. 1A). The patient then underwent a non-contrast, chest photon-counting CT scan (NAEOTOM Alpha; Siemens Healthineers, Forchheim, Germany) to determine the location and extent of the extracapsular silicone within the heterogenous appearing right breast (Fig. 1B) and within hyperattenuating, enlarged axillary and internal mammary lymph nodes (Fig. 1C).

To help answer these diagnostic questions, we used our custom software to generate silicone-specific segmentation images (i.e., silicone maps) from the photon-counting CT data [10,11]. This software used a two-dimensional (2D) histogram of the 40-keV and 190-keV monoenergetic data. The unique location of silicone within this 2D histogram allowed for material differentiation and visual segmentation of silicone within the photon-counting CT images. Examples of the pre-segmented CT image, the corresponding 2D histogram, and the resulting silicone segmented CT image are shown in Fig. 2A-C, respectively.

Our custom photon-counting CT silicone maps for this patient (1) allowed differentiation of extracapsular silicone

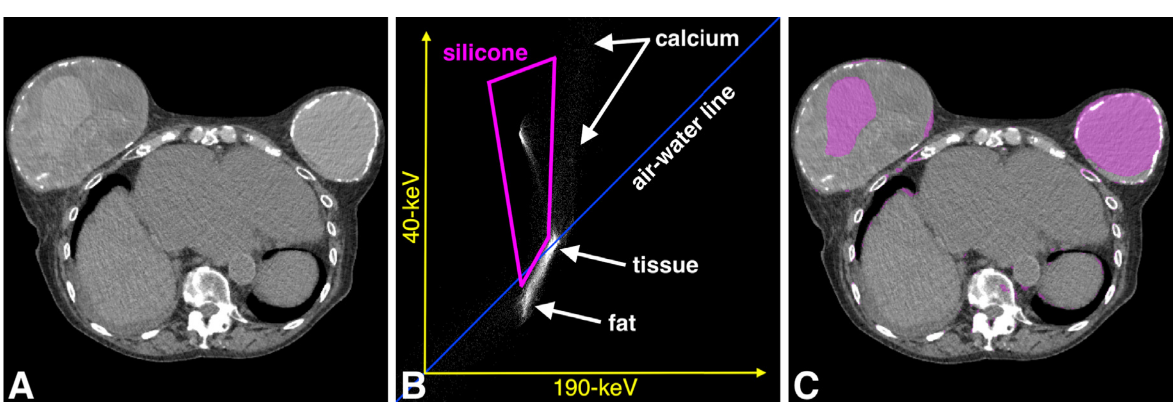

Fig. 2 – (A) 70-keV monoenergetic photon-counting CT showing heterogenous appearing silicone, hematoma, and calcium within the breasts. (B) 2D histogram of the 40-keV and 190-keV monoenergetic photon-counting CT data from the axial section in A. Note that silicone has a unique 2D location from calcium, fat, and non-enhancing tissue. (C) Custom silicone-specific segmented image of A based on the pink quadrilateral ROI in B that identifies voxels containing silicone. All CT image window level/width = 40/400 HU.

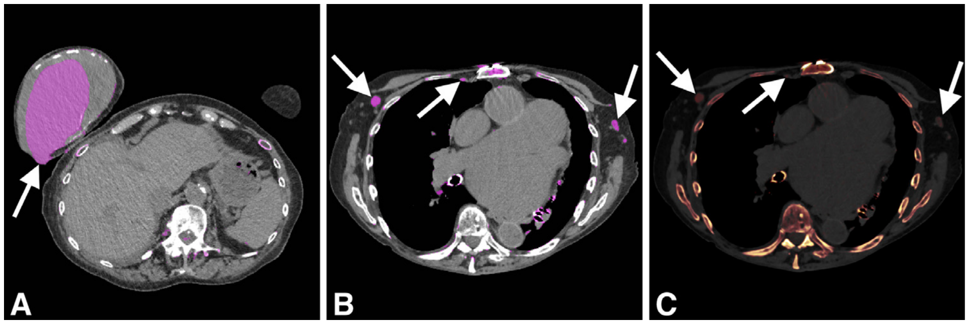

Fig. 3 – (A) Our custom silicone segmented image that differentiated extracapsular silicone from hematoma and calcium in the right breast and assessed the fistula (arrow). (B) Our custom silicone segmented image of Fig. 1C revealing silicone-laden lymph nodes (arrows). (C) Silicone segmentation image of Fig. 1C using the prior dual-energy CT methods (i.e., syngo.CT Dual Energy VB70; Siemens Healthineers) where arrows point to silicone-laden lymph nodes. Note that silicone and calcium are not differentiated in (C). (A) and (B) CT image window level/width = 40/400 HU.

from hematoma and calcium within the right breast (Fig. 3A), (2) provided anatomic assessment and location of the fistula (Fig. 3A), and (3) revealed bilateral silicone-induced lymphadenopathy (Fig. 3B). A comparison to the prior dual-energy CT methods [6-9], where silicone and calcium are not differentiated, is shown in Fig. 3C.

Discussion

Ultrasound imaging can be useful for silicone breast implant evaluation in patients with contraindications to MRI. However, ultrasound is not the ideal modality for either emergency imaging or routine screening, especially for patients with implant ruptures, breast calcifications, or both. This case report demonstrated the potential for first-generation clinical photon-counting CT systems to perform volumetric silicone-specific segmentation as an alternate to both MRI and ultrasound breast imaging. Furthermore, the extracorporeal extrusion of breast implant material after cosmetic augmentation seen in this patient is a rare event with few cases reported in the literature [12].

Prior clinical publications have also demonstrated the potential for dual-energy CT to perform volumetric silicone-specific segmentation [6-9]. However, these prior methods were only shown for a single vendor, had field of view limitations, and could not differentiate calcium from silicone. In contrast, our initial clinical data showed that emerging spectral CT methods can differentiate silicone from calcium and have the potential to be translated to all spectral CT scanners with monoenergetic image capabilities (i.e., all dual-energy CT and photon-counting CT scanners).

One current limitation of these methods is that spectral CT silicone maps have yet to be FDA approved under any vendor, and therefore require custom in-house reconstructions.

However, some vendors do offer software tools for such off-label applications (e.g., syngo.CT Dual Energy VB70; Siemens Healthineers, Forchheim, Germany) [13]. Another limitation of this method is that CT uses ionizing radiation, unlike MRI and ultrasound. However, the radiation dose to the patient could be reduced by a factor of two using the improved contrast-to-noise ratio and special tin filtration technique available in photon-counting CT systems compared with conventional dual-energy CT systems [14,15].

In conclusion, we have used a custom method to differentiate and segment silicone in photon-counting CT images. This new method showed that, similar to dual-energy CT, photon-counting CT can be used as an imaging alternative for patients with contraindications to MRI. Additionally, this new custom method can differentiate silicone from calcium with reduced scan time and cost compared to MRI.

Patient consent

Written informed consent for the publication of this case report was obtained from the patient.

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