SARS-CoV-2 mRNA Vaccination Causes Prolonged Increased Cortical Thickening and Vascularity in Ipsilateral Axillary Lymph Nodes

Sharlene A. Teefey, MD ©, William D. Middleton, MD ©, Jackson S. Turner, PhD, Ali H. Ellebedy, PhD, Teresa Suessen, PA-C, Michael Wallendorf, PhD, Jane A. O’Halloran, MD, PhD, Rachel Presti, MD, PhD

Objectives—To describe the serial grey-scale and color Doppler appearance of ipsilateral axillary lymphadenopathy in response to the Pfizer-BioNTech Severe Acute Respiratory Syndrome Coronavirus (SARS-CoV-2) messenger RNA (mRNA) vaccine over 24 to 28 weeks.

Methods—The data for this study were collected during an observational study to determine whether mRNA vaccination induced a germinal center B cell reaction in blood and draining axillary lymph nodes. The current study evaluated the serial color Doppler and grey-scale sonographic appearance of these lymph nodes. Ten participants who each underwent 6 sonograms and FNAs over 24 to 28 weeks were included in the study. A total of 11 lateral lymph nodes were identified. Cortical thickness was measured and absence or presence of color Doppler flow in the hilum and lymph node cortex was graded (scale: 0–2).

Results—Eleven lateral axillary lymph nodes were biopsied over 24 to 28 weeks. Mean thickness varied through time (P < .001) and was greater weeks 2 to 7 compared to weeks 24 to 28 (mean differences of 2.6 to 1.3; P < .006), but weeks 14 to 17 mean thickness was not different from weeks 24 to 28 (0.57; P = .15). Cortical vascularity was increased in all 11 lymph nodes by week 5. Mean vascularity varied through time (P < .001) and was greater weeks 2 to 14 compared to weeks 24 to 28; mean differences ranged from 1.7 to 0.83 (P < .001).

Conclusions—Serial grey-scale and color Doppler appearance of ipsilateral axillary lymph nodes after mRNA vaccination manifest as increased and prolonged cortical thickening and vascularity that diminishes and approaches normal by 24 to 28 weeks.

Key Words—axillary lymphadenopathy; mRNA vaccine; ultrasound

Severe acute respiratory syndrome coronavirus (SARS-CoV-2) is responsible for one of the most devastating pandemics humanity has experienced. As of February 24, 2022, there were 431.2 million cases of SARS-CoV-2 and 5.93 million deaths worldwide. Its emergence resulted in the first FDA-approved vaccine using the novel messenger RNA (mRNA) technology platform. These mRNA vaccines induce robust B cell responses, including persistent spike-specific germinal center (GC) B cell responses in the draining axillary lymph nodes.
A safety and efficacy study of 43,448 participants who were randomized to receive an mRNA vaccine (Pfizer-BioNTech, New York, NY) or a placebo reported several side effects from the vaccine including ipsilateral axillary lymphadenopathy in 0.3% of participants. The Centers for Disease Control reported vaccine-induced axillary lymphadenopathy after administration of the Moderna vaccine in 16.0% of participants after the second dose.

In early 2021, reports of post-vaccine axillary lymphadenopathy identified on ultrasound, CT, PET/CT, MRI, and mammography began to appear online and in the literature. Recommendations for the management of post-vaccine axillary lymphadenopathy were subsequently published by several groups; follow-up intervals varied and ranged from 2 to 12 weeks after the second dose based on the patient’s clinical, oncologic, and vaccine history.

In a recent study we participated in, ultrasound scans and fine needle aspirations (FNA) of axillary lymph nodes were performed to assess the GC B cell response in participants who had received 2 doses of BNT162b2 (Pfizer-BioNTech), an mRNA vaccine for SARS-CoV-2. Our study provided a unique opportunity for us to evaluate the sonographic appearance of draining axillary lymph nodes after administration of an mRNA vaccine over a 24- to 28-week period. The purpose of our study was to describe the serial grey-scale and color Doppler appearance of these axillary lymph nodes in response to the mRNA vaccine.

Materials and Methods

The data for our study were collected during a prospective observational study that we participated in that was designed to determine whether SARS-CoV-2 vaccination induced a GC B cell reaction and a durable antibody response by evaluating antigen-specific B cell responses in peripheral blood and draining axillary lymph nodes. For that study, serial blood samples were obtained, ultrasound scans and axillary lymph node FNAs were performed and standard immunological assays were run. Our study evaluated the serial color Doppler and grey-scale sonographic appearance of these draining axillary lymph nodes. This Health Insurance Portability and Accountability Act (HIPPA) compliant study was approved by our institutional review board. Written consent was obtained from all participants. The ultrasound scans were performed and FNA samples were collected between January and August 2021.

Forty-one adults (eight of whom had a confirmed history of prior SARS-CoV-2 infection) who received the Pfizer-BioNTech SARS-CoV-2 mRNA vaccine BNT162b2 were recruited to the SARS-CoV-2 vaccine study by word of mouth and Volunteers for Health, a University based group that runs a research registry data base. Inclusion criteria included men or women age 18 years or older and in good health as determined by a review of their medical history and targeted physical examination guided by their history, ability to attend all study visits and ability to understand and give consent. Exclusion criteria included pregnancy, allergy to a vaccination, history of Guillain-Barre post-vaccination, impaired immunity, HIV, a chronic medical illness requiring hospitalization within the 3 previous months, chronic corticosteroid use, and drug or alcohol abuse. Sixteen of the participants agreed to undergo serial ultrasound-guided axillary lymph node FNAs and were enrolled in the study.

Of the 16 participants who were enrolled in the SARS-CoV-2 vaccine study, 4 participants did not undergo all 6 axillary lymph node FNAs, a fifth had inadequate lymph node sampling and a sixth had the 2 doses of the vaccine administered in different arms. These participants were excluded from our study. The remaining 10 participants who had both vaccines administered in the same arm and underwent 6 scans and FNAs with adequate sampling were included in our study. There were 5 men and 5 women between the ages of 28 and 48 years. None of these 10 participants had a history of prior SARS-CoV-2 infection.

The first scan and FNA were performed 2 to 3 weeks after the first vaccination but prior to the second vaccination and at weeks 4, 5, 7–8, 14–17, and 24–28 after the first vaccination (Figure 1). The second vaccination was administered prior to the week 4 scan. In 1 participant, the scan and FNA were performed week 20 rather than weeks 14 to 17, and in another participant, the last scan and FNA were performed at week 32 rather than weeks 24 to 28 due to scheduling conflicts. A baseline scan and FNA were not performed prior to the administration of the first
of 2 vaccinations because the participants were vaccinated during a very short time interval and it was not possible to schedule all 10 and perform an axillary lymph node FNA during that time. However, if participants were scanned prior to the first vaccination, it would have been difficult to determine which lateral axillary lymph node would have responded to the vaccine if more than one was identified. Lateral lymph nodes can number up to 6. In fact, in 3 participants, a second lymph node with a thick cortex was identified 1 week after the second vaccination indicating it had also responded to the vaccine. These three axillary lymph nodes were scanned and biopsied weeks 4, 5, 7–8, and 14–17 and at 6–7 months after the first vaccination.

All sonograms were performed using a Logiq E10 ultrasound machine (GE Health Care Systems, Chicago, IL) and 6 to 15 MHz or 9 MHz linear transducer. The scan and ultrasound-guided FNA of one or more axillary lymph nodes was performed on the ipsilateral side of the vaccination site. The participant was placed in a supine position with the arm abducted and the elbow bent to 90° to expose the axilla. A 25-gauge needle was used for all aspirates. An attempt was made to identify a lateral lymph node that was located adjacent to the axillary vein. Lateral lymph nodes are the first to receive the lymphatic drainage from the upper limb that includes the deltoid muscle vaccination site and therefore are the most likely lymph nodes to have a response to the vaccine. If a lateral lymph node could not be identified, the closest lymph node to the axillary vein (a secondary lymph node) with the thickest cortex was selected for FNA. All lymph nodes were located at a depth accessible to FNA. However, FNA of some lymph nodes whose cortex decreased in thickness over time was more challenging. Nevertheless, adequate sampling was confirmed at tissue analysis in all lymph nodes (2).

All lymph nodes identified for FNA by ultrasound were measured in the longitudinal, transverse, and anterior–posterior planes. The thickest part of the cortex was measured in the short axis in the transverse plane and all values were recorded in millimeters to 1 decimal point. The lymph node cortical thickness was also recorded as diffuse or focal. The depth of the lymph node from the skin surface and distance from the axillary vein was measured to aid in identifying the lymph node at subsequent scans and FNAs. Video clips were also taken for visual reference and prior images were reviewed at the time of each repeat scan and FNA.

The reference standard used for the upper limits of normal for cortical thickness for an axillary lymph node was 3 mm. An increase in cortical thickness was considered present when the thickness measured greater than 3 mm.

The absence or presence of color Doppler flow in the hilum and cortex of the lymph node was evaluated on static images and video clips using low flow color Doppler parameters. The absence of color Doppler flow in a lymph node or only hilar flow was scored as 0, mild color Doppler flow in the cortex (a few uniform hilar and cortical vessels) was scored as 1 and moderate to marked color Doppler flow in the cortex (robust, uniform hilar and color Doppler flow in a larger portion of the cortex) was scored as 2. Increased cortical vascularity was considered present if a lymph node was scored as 1 or 2.

All scans and FNAs were performed by either an experienced certified physician’s assistant specialized in ultrasound with 22 years of experience who was directly supervised by 1 of 2 radiologists or by a radiologist independently. Both radiologists have more than 30 years of experience in ultrasound. An ultrasound report was generated that included lymph node measurements and a vascularity score based on static imaging and video clips. Image analysis was performed prior to acquiring 6 aspirates through the thickest part of the lymph node cortex. One of the radiologists reviewed all data in each ultrasound report; any disagreements between the reported

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**Figure 1.** Timeline of scans/FNAs and vaccinations. 0–28: weeks from the first vaccination. V1: first vaccination. V2: second vaccination. Blue arrows indicate when scans/finene needle aspirations (FNAs) were performed.
findings and the reviewer’s interpretation were resolved by consensus between the 2 radiologists who participated in the study.

Vascularity and cortical thickness were analyzed in the 11 draining (lateral) lymph nodes in the 10 participants for changes through time post-vaccination. A mixed random effects repeated measures model was used where time was a fixed effect and subject was random. Degrees of freedom were adjusted with Kenward-Rogers method and within subject auto-correlation was corrected with a first-order autoregressive covariance structure. Means were compared between week 24 and each previous time point in 5 predetermined independent contrasts.

Results

The 10 participants in our study had a total of 13 axillary lymph nodes identified and biopsied during the study. Ten lymph nodes were first identified at the time of the initial scan (9 were lateral lymph nodes and 1 was a secondary lymph node) that was performed 2 to 3 weeks after the first vaccination but prior to the second vaccination. Three additional lymph nodes (2 were lateral lymph nodes and 1 was a secondary lymph node) were first identified at the time of the second scan that was performed 4 weeks after the first vaccination and 1 week after the second vaccination.

Of the 13 lymph nodes identified during the study, 11 were lateral lymph nodes and 2 were secondary lymph nodes. Nine of 11 (82%) lateral lymph nodes were identified on the initial scan and 2 were identified on the second scan. Cortical thickening was present in all 11 lymph nodes at the time they were first detected (2–3 or 4 weeks after the first vaccination) and measured between 3.5 and 8.4 mm. The lymph node cortex was focally thickened in 6 of 11 (55%) lymph nodes and diffuse in 5 of 11 (45%).

Figure 2. Focal cortical thickening in a left ipsilateral axillary lymph node after messenger RNA (mRNA) vaccination in a 37-year-old man. A, Longitudinal sonogram of the lymph node showing the normal thin cortex (arrows) and an area of focal cortical thickening (cursors +) that measures 0.37 cm. The image was obtained 2 weeks after the first vaccination. B, Longitudinal sonogram of the same lymph node showing the normal thin cortex (arrows) and a decrease in focal cortical thickening (cursors +) to 0.21 cm. The image was obtained 6 months after the first vaccination. C, Longitudinal color Doppler image of the same lymph node showing moderate to marked increased cortical vascularity. The image was obtained 2 weeks after the first vaccination. D, Longitudinal color Doppler image of the same lymph node showing loss of cortical vascularity and only hilar vascularity. The image was obtained 6 months after the first vaccination.
Figures 2A and 3A show focal and diffuse cortical thickening in 2 different lymph nodes in the same participant. Figure 4A shows focal cortical thickening in a lateral lymph node in a different participant. Cortical thickening persisted to weeks 7 to 8 in 9 of 11 (82%) lymph nodes and to weeks 14 to 17 in 6 of 9 (67%) lymph nodes (Figure 4B). Nine of 11 (82%) lymph nodes could be identified weeks 24 to 28 and 5 of 9 (56%) had persistent cortical thickening. Figures 2B and 3B show a decrease in focal and diffuse cortical thickening over time, respectively. Mean thickness for the 11 lateral lymph nodes varied through time (P < .001). Using a mixed random effects repeated measures model, mean thickness was greater weeks 2 to 7 compared to weeks 24 to 28 (mean differences of 2.6–1.3; P < .006), but mean thickness weeks 14 to 17 was not different from weeks 24 to 28 (0.57; P = .15; Figure 5).

Increased cortical vascularity was present in 6 of 9 (67%) lateral lymph nodes identified on the initial scan (2–3 weeks after the first vaccination). Figures 2C and 3C show increased cortical vascularity in the same 2 lymph nodes shown in Figures 2A and 3A. Figure 4C shows moderate to marked cortical vascularity in a different participant. At week 5,

Figure 3. Diffuse cortical thickening in a second ipsilateral axillary lymph node after messenger RNA (mRNA) vaccination in a 37-year-old man (same man as Figure 2). A, Longitudinal sonogram of the lymph node showing diffuse cortical thickening (cursors +) that measures 0.51 cm. The image was obtained 4 weeks after the first vaccination. B, Longitudinal sonogram of the same lymph node showing a decrease in diffuse cortical thickening (cursors +) to 0.28 cm. The image was obtained 6 months after the first vaccination. C, Longitudinal color Doppler image of the same lymph node showing marked increased cortical vascularity. The image was obtained 4 weeks after the first vaccination. D, Longitudinal color Doppler image of the same lymph node showing loss of cortical vascularity and only hilar vascularity. The image was obtained 6 months after the first vaccination.
increased cortical vascularity was present in all 11 lateral lymph nodes (including the 2 lymph nodes detected on the second scan) and persisted to weeks 7 to 8 in all 11 and to 14 to 17 weeks in 6 of 11 (55%) lymph nodes. Five of 6 (83%) lymph nodes could be identified at weeks 24 to 28; cortical vascularity was absent or only hilar flow was detected (score 0) in all 5 of these lymph nodes. Figures 2D and 3D show a loss of cortical vascularity over time. Figure 4D shows a decrease in cortical vascularity over time in a different participant. Mean vascularity for the 11 lateral lymph nodes varied through time ($P < .001$). Using a mixed random effects repeated measures model, mean vascularity was greater weeks 2 to 14 compared to weeks 24 to 28; vascularity mean differences ranged from 1.7 to 0.83 (scale of 0–2; $P < .001$; Figure 6).

Two secondary lymph nodes were identified in 1 participant. One lymph node was identified at the time of the initial scan 2 to 3 weeks after the first vaccination; no lateral lymph node could be identified in this participant. Cortical thickness increased week 5 and persisted to week 15. This lymph could not be identified week 28. Cortical thickness ranged between 3.6 and 6.5 mm and was diffuse. The other secondary lymph node was identified week 4. Cortical thickness was increased at week 4 and persisted to week 28. Cortical thickness ranged between 4.5 and 6.7 mm and was focal. There was no detectable vascularity in either secondary lymph node throughout the study.

**Figure 4.** Focal cortical thickening in a left ipsilateral lymph node after messenger RNA (mRNA) vaccination in a 29-year-old woman. **A,** Transverse sonogram of the lymph node showing focal cortical thickening that measures 0.84 cm. The image was obtained 2 weeks after the first vaccination. **B,** Transverse sonogram of the same lymph node showing persistent focal cortical thickening that measures 0.82 cm. The image was obtained 17 weeks after the first vaccination. **C,** Transverse color Doppler image of the same lymph node showing moderate to marked cortical vascularity. The image was obtained 2 weeks after the first vaccination. **D,** Transverse color Doppler image of the same lymph node showing mildly increased cortical vascularity. The image was obtained 17 weeks after the first vaccination.
Discussion

Since the SARS-CoV-2 vaccine became widely available in late December of 2020, numerous case reports and articles have appeared in the literature reporting the incidental detection of ipsilateral axillary lymphadenopathy after administration of an mRNA vaccine.\textsuperscript{5–12} Because the differential diagnosis for axillary lymphadenopathy includes lymphoma and metastatic disease, in particular, in breast carcinoma, concerns were raised by both patients and clinicians that prompted the development of several management recommendations. However, follow-up intervals varied and ranged from no further follow-up to follow-up in 2 to 12 weeks.\textsuperscript{5,7,8,10,11,13–15} In an effort to provide clinicians with guidance when evaluating patients with post-vaccine ipsilateral lymphadenopathy, we evaluated the serial grey scale and color Doppler appearance of axillary lymphadenopathy after mRNA vaccination. Our findings showed that lymphadenopathy manifests as increased and prolonged cortical thickening and vascularity that diminishes and approaches normal by 24 to 28 weeks.

At the time of the initial scan, 2 to 3 weeks after the first vaccination, we found that cortical thickness was increased in the 9 lateral lymph nodes identified and cortical vascularity was increased in two-thirds of these lymph nodes. Lateral lymph nodes are the first to receive lymphatic drainage from the vaccine and therefore the first to undergo a GC B cell response to the antigen (vaccine). The GC B cell response, a complex process of activation, proliferation, and differentiation of B cells, is first visible in primary draining lymph nodes 3 to 4 days after initial exposure to an antigen, peaks by 7 to 10 days and persists for 2 to 3 weeks unless there is a second antigenic stimulus that would prolong the response.\textsuperscript{18} In our SARS-CoV-2 vaccine study, antibody secreting plasmablasts (immature plasma cells) were detected in blood 2 to 3 weeks after the first vaccination confirming that a GC B cell response had already occurred in these 9 lateral lymph nodes prior to the initial scan and FNA.\textsuperscript{2} The sonographic findings of increased cortical thickness and vascularity therefore represent the gross morphologic changes of a reactive lymph node due to the robust GC B cell response induced by the vaccine-specific antigen.\textsuperscript{2}

We found that cortical thickening gradually decreased over time in all 11 lateral lymph nodes. Of the 9 lateral lymph nodes that could be identified at weeks 24 to 28, cortical thickening persisted in slightly more than 50% of these lymph nodes but was decreased compared to earlier measurements.
indicating a prolonged, immune response in these primary (lateral) draining lymph nodes.

We also found that increased cortical vascularity, which is likely due to local vasodilation caused by the release of inflammatory mediators, diminished over time. Increased cortical vascularity was present by week 5 in all 11 lateral lymph nodes and persisted to weeks 14 to 17 in slightly greater than 50% of lymph nodes. Unlike cortical thickening, increased cortical vascularity resolved by 24 to 28 weeks in all 9 of the lateral lymph nodes that could be identified indicating a return to normal. Interestingly, cortical vascularity was never detected in either of the 2 secondary lymph nodes. It is difficult to explain the absence of cortical vascularity in these secondary lymph nodes given the substantial increase in cortical thickness in response to the vaccine. One of these lymph nodes had a thin (3 mm) cortex on the initial scan and it may have been more difficult to demonstrate color Doppler flow, however, cortical vascularity also could not be demonstrated when the cortex measured 6.5 mm at week 5.

Two published ultrasound studies that also followed subjects serially showed an increase in lymph node size and vascularity post mRNA vaccination. A prospective study by Igual-Rouilleault et al. evaluated 91 volunteers with 3 ultrasounds prior to and 1 week after the 3 ultrasound studies. Of the 66 lymph nodes assessed at the initial study, central and peripheral vascularity using superb microvascular imaging was detected in 50% of lymph nodes, hilar flow in 45.8%, and only peripheral vascularity in 4.2%. Cortical thickness was not measured but lymph node size was measured, although the axis measured was not specified. The median lymph node size reported was 0.9 cm ± 0.19. Sonograms were repeated every 2 weeks in 12 patients until lymph nodes normalized.

The average number of days for lymph nodes to normalize was 26.9 ± 14.7.

There are methodological differences between our study and the 2 studies by Igual-Rouilleault et al and Cocco et al that may explain the disparities between our results and theirs. First, subjects in the 2 studies were not followed for 24 to 28 weeks. But more importantly, it is not evident in either study that each individual lymph node identified on the first scan was serially followed and evaluated for all sonographic features listed by the authors on each subsequent scan. Furthermore, neither study stated how they determined that a lymph node evaluated on a follow-up scan was the same lymph node identified on the first scan; this is critical when evaluating ultrasound features of individual lymph nodes over time. In fact, in Igual-Rouilleault et al’s study, the authors stated that in order to record the maximum value for each sonographic variable, different lymph nodes were selected if necessary indicating that their results reflect serial sonographic changes in groups of lymph nodes rather than in individual lymph nodes. Coco et al’s study which was retrospective also reports serial changes in groups of lymph nodes rather than in individual lymph nodes. Finally, neither study stated if the lymph nodes followed were lateral (primary draining) or secondary lymph nodes or both. Lateral lymph nodes are the primary draining lymph nodes of the deltoid muscle and likely will have a more robust and prolonged response to the vaccine than secondary lymph nodes. Lateral nodes are deeper and more difficult to identify, particularly if there is not a dedicated, prospective search for them. It is very likely that some axillary lymph nodes that were evaluated in these 2 studies were secondary lymph nodes that did not have an intense response to the vaccine; this could explain the earlier normalization of the lymph nodes in their studies compared to ours.

A review by Keshavarz et al of 19 imaging studies (68 cases) including FDG/PET CT, MRI, and ultrasound reported findings of axillary or supraclavicular lymphadenopathy following mRNA
vaccination. 97% of cases of lymphadenopathy were identified between day 1 and 4 weeks after vaccination and persisted to 5 to 6 weeks in only 2 cases. Based on these findings, most of these studies recommended routine imaging screening before or at least 4 to 6 weeks after the second vaccine dose. However, the methodology of the ultrasound studies including duration of follow-up of individual lymph nodes, if individual lymph nodes were followed serially and what features were followed, and identification of lymph nodes as lateral or secondary was not described in detail in this review which may account for the differences reported in this review and our study.

The sonographic findings of increased and prolonged cortical thickening and vascularity that we observed in the axillary lymph nodes post mRNA vaccination reflect the immunologic changes that occurred from the vaccine-specific antigen. The goal of most currently licensed human vaccines is to generate antigen-specific long-lived plasma cells (LLPCs) and memory B cells (MBCs). LLPCs provide the host with a persistent source of protective antibodies and are needed to maintain durable immune protection following vaccination. MBCs quickly expand and differentiate into antibody secreting plasma cells upon antigen re-exposure. Thus, LLPCs and MBCs are the end products of the GC reaction. In comparison, while the influenza vaccine can elicit a GC B cell response to the influenza virus, the response is much less robust. Influenza vaccines predominantly stimulate pre-existing MBCs that selectively recall specific antibodies from previous exposures to other influenza viral antigens rather than inducing a de novo GC B cell response.

There are limitations to our study. First, the sample size was small because it was difficult to recruit participants who would agree to undergo lymph node scans and FNAs during a 24-week period. It was also difficult to biopsy participants precisely at 16 and 24 weeks due to scheduling conflicts; the timing of later scans and FNAs ranged between weeks 14 and 17 and 24 and 28 weeks in most participants. Furthermore, the number of secondary lymph nodes identified was very small but our goal was to evaluate primary (lateral) draining lymph nodes and 11 lateral lymph nodes were identified in the 10 participants during the 24- to 28-week study period. Third, a pre-vaccination axillary lymph node scan and FNA were not performed that would have provided baseline data for cortical thickness and vascularity. However, because multiple lateral lymph nodes may exist, it would not have been known which lateral lymph node would respond to the vaccine. If a lymph node was chosen for biopsy prior to vaccination that did not respond to the vaccine, that data would not have been relevant. Furthermore, the mean thickness of the 11 lateral lymph nodes was greater weeks 2 to 7 compared to weeks 24 to 28 indicating the lymph nodes were returning or had returned to their “normal” baseline size.

In conclusion, our ultrasound study is the first to our knowledge to describe the serial grey-scale and color Doppler appearance of individual ipsilateral axillary lymph nodes in response to an mRNA vaccine for 24 to 28 weeks. Our recently published SARS-CoV-2 study provides the first direct evidence that these sonographic findings of increased and prolonged cortical thickening and vascularity post-vaccination are the direct result of GC B cell activation specifically induced by the mRNA vaccine and directed at the spike protein. Although the number of participants in this study is small, our findings can provide guidance to clinicians when ipsilateral axillary lymphadenopathy is detected post-vaccination. In healthy patients without an oncologic history, imaging follow-up may not be indicated and patients can be counseled that lymphadenopathy may not return to normal until 24 to 28 weeks. In patients with an oncologic or other pertinent clinical history, clinicians should be aware of the prolonged response of ipsilateral axillary lymph nodes to the mRNA vaccine when considering imaging follow-up.

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