Diagn Interv Radiol 2013; 19:208–212

CHEST IMAGING
ORIGINAL ARTICLE

Poststernotomy lymphadenopathy: prevalence, size, and location on chest CT

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PURPOSE
We aimed to determine the prevalence of enlarged lymph nodes (LNs) in chest computed tomography (CT) scans of patients with a history of sternotomy.

MATERIALS AND METHODS
The chest CT scans of 271 patients with a history of sternotomy (mean age, 68.3±14.4 years; range, 15–93 years; 178 males) were retrospectively scored in a blind and random manner for the presence, size, and location of enlarged LNs. Scans with known etiologies for enlarged LNs were excluded. Serial scans were available for 15 patients with enlarged LNs. Twenty patients (mean age, 61.2±7.0 years; range, 54–64 years; 15 males) that had cardiac CT data with no cardiac surgery were included as controls.

RESULTS
Of the 271 patients, 189 had other identifiable etiologies for enlarged LNs. Of the remaining 82 patients, 36 (44%) demonstrated enlarged LNs. None of the control patients presented with enlarged LNs (n=20). The mean size of the enlarged nodes was 13.0±2.0 mm. Enlargement of the lymph nodes in station 4R was most common (n=18, 50%; size, 13.1±2.0 mm), followed by the enlargement of nodes in station 7 (n=16, 44%; size, 12.3±2.2 mm). The majority of patients had one (n=20, 56%) or two (n=12, 33%) nodal stations that showed enlargement. We did not observe any significant association between the number or types of grafts and enlarged LNs. Serial CT scans did not show any significant changes in LN enlargement for any nodal station.

CONCLUSIONS
Enlarged mediastinal and/or hilar LNs are common in patients with a history of previous sternotomy. It is important for radiologists to be aware of this association to avoid misdiagnosis and further unnecessary procedures for nodal sampling.

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Received 28 August 2012; revision requested 24 September 2012; revision received 16 October 2012; accepted 17 October 2012.

Published online 9 Jaunary 2013
DOI 10.5152/dir.2013.015

Chest computed tomography (CT) is highly accurate in the detection of enlarged mediastinal and hilar lymph nodes (LNs) (1, 2). The underlying etiologies of LN enlargement include infections, neoplasms, fibrosis, granulomatous inflammation as well as heart-failure and drug-related etiologies (3). While CT is highly sensitive in detecting lymph node enlargement, it lacks specificity; it cannot distinguish between benign and malignancy-related enlargements (4). When abnormalities of the LNs are detected, it typically results in serial surveillance CT scans, and sometimes in procedures such as mediastinoscopy and endobronchial ultrasonography (US), which are associated with significant morbidity and increased costs (4, 5). It is, therefore, extremely useful to determine the association between underlying etiopathologies and benign enlarged LNs to avoid unnecessary invasive procedures, and instead to focus on surveillance.

Interestingly, we have anecdotally noted that many patients with a history of open cardiac surgery subsequently develop mildly enlarged LNs visible on chest CT scans that remain stable over time. Between 2007 and 2008, 1081 coronary artery bypass grafts (CABGs) were carried out per million people in the USA (6). Revascularisation with CABG is usually done when there is a large amount of myocardium at risk from coronary artery disease, intermediate-high SYNTAX scores, or diffuse three-vessel coronary disease, particularly in patients with diabetes (7). The second most common indication for sternotomy is cardiac valve replacement. In 2006, 16 330 aortic valve replacements were carried out, according to the Society of Thoracic Surgeons National Database (8). In addition, between 2000 and 2007, 58 370 mitral valve procedures were performed for isolated mitral valve disease (9). In light of our anecdotal observations regarding sternotomy-involving cardiac surgeries and enlarged LNs, in this study we aimed to determine the prevalence and location of these enlarged lymph nodes.

Materials and methods

Patients

The radiology database of our hospital was initially reviewed for all patients who had undergone sternotomy for cardiac surgery between 1990 and 2011. Of the 271 consecutive scans fulfilling these criteria (mean age, 68.3±14.4 years; range, 15–93 years; 178 males), 189 were excluded, leaving 82 in the final analysis. Exclusion criteria included concurrent chest infection (including pneumonia, mediastinitis, pericarditis, or endocarditis), cardiothoracic surgery within the previous three months, acute pulmonary edema, immunosuppression, cancer, evidence of previous granulomatous infection, evidence of chronic interstitial lung disease, underlying connective tissue disease, and drug or environmental exposure known to cause enlarged LNs (3). The study received institutional ethics board approval.

All patients underwent helical 64-slice multidetector CT (Siemens Sensation 64, Siemens Medical Systems, Erlangen, Germany) of the thorax from apex to lung bases in the supine position at maximal inspiration. Two hundred and fifty three patients had intravenous contrast administered, while 18 cases were noncontrast CT. We included 20 consecutive patients (mean age, 61.2±7.0 years; range, 54–64 years; 15 males) who had undergone cardiac CT for the investigation of atypical chest pain, but who had not undergone any cardiac surgery as controls. Inclusion criteria for the controls were low or intermediate pre-test likelihood of obstructive coronary artery disease, and exclusion criteria were identical to the ones for the active cohort. All images were evaluated using a Syngo imaging workstation (Siemens Medical Systems). Serial CT scans were available for a subgroup of 15 patients with enlarged LNs, with a mean follow-up time of 21 months.

Image analysis

Images were reconstructed using a range of slice thicknesses (1.0–5.0 mm) with appropriate mediastinal window width and centre to maximize lymph node analysis (general window width, 350–450 Hounsfield unit [HU]; window level, 30–50 HU). The CT scans were retrospectively reviewed by two observers (C.J.M., J.D.D.), who reached a decision by consensus. Enlarged lymph nodes were defined as those with a diameter of 10 mm or more in the short axis (3). We chose this diameter length, even though certain nodal stations (e.g., the subcarinal station) may include normal nodes measuring >10 mm, because 10 mm is still the most widely used cut-off in everyday clinical practice (3). The distribution of enlarged LNs was recorded according to the latest tumor, node, and metastasis (TNM) staging system proposed by the International Association for the Study of Lung Cancer (Fig. 1) (10, 11). Data collected included the number of scans demonstrating enlarged LNs,

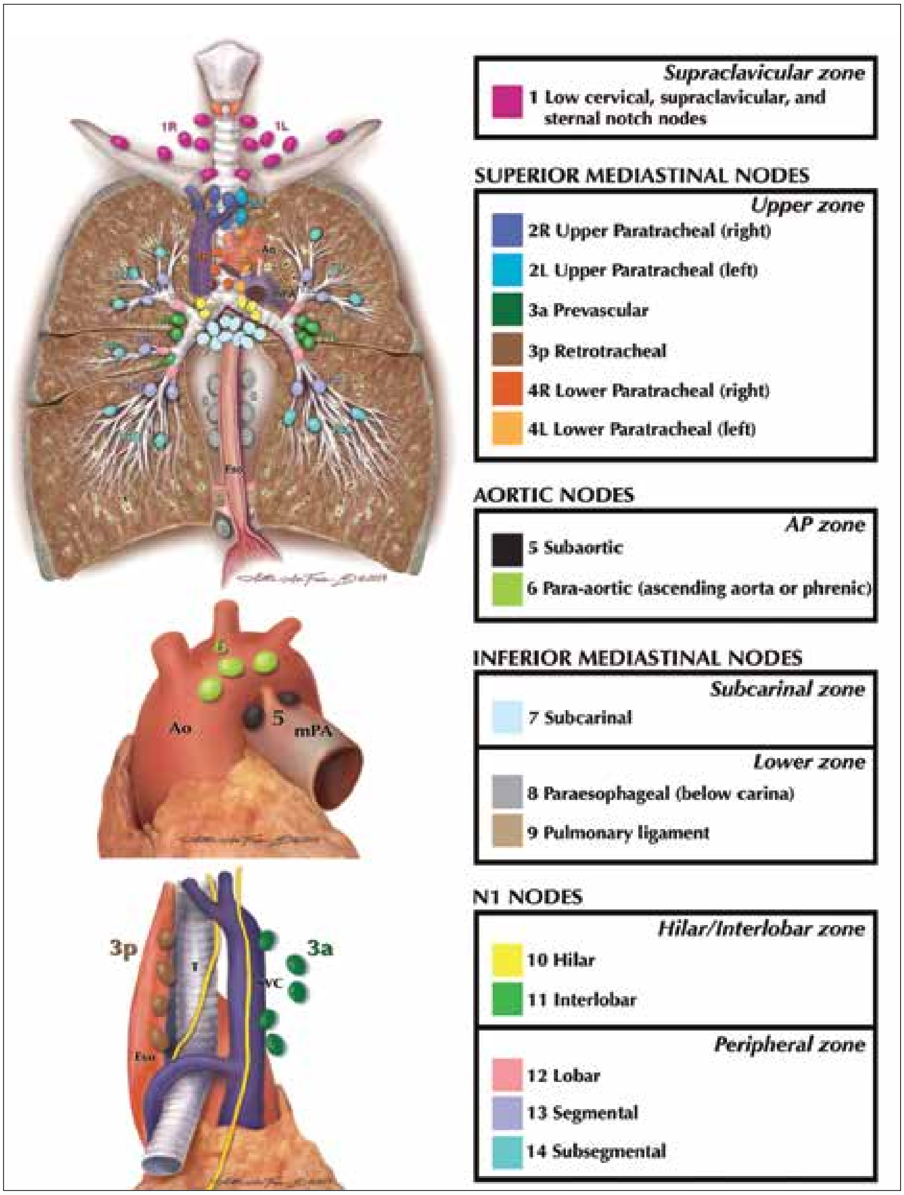

Figure 1. Lymph node stations used in scoring (reproduced with permission from Rusch et al. [10]).

station location, size (obtained in axial images using electronic callipers), number of grafts (in patients with CABGs), graft location, and location of prosthetic valves (in patients with valve replacements).

Statistics

Patient demographics are provided as the mean±standard deviation. Comparisons between groups for numerical values were performed using the independent t test. Correlations were assessed using the Spearman Rank test. Stepwise logistic regression analysis was performed between groups with "enlarged LNs" as the dependent variable, and "age," "gender," "surgical procedure," "number of grafts," and "type of valve" as independent variables. All statistical analyses were performed using computer software (Statistical Package for Social Sciences, version 18.0, SPSS Inc., Chicago, Illinois, USA). *P* values less than 0.05 were considered to indicate a significant difference.

Results

Of the 271 consecutive patients, 189 were excluded. Reasons for exclusion included malignancy (n=67), active chest infection (n=63), previous granulomatous disease (n=20), acute pul-

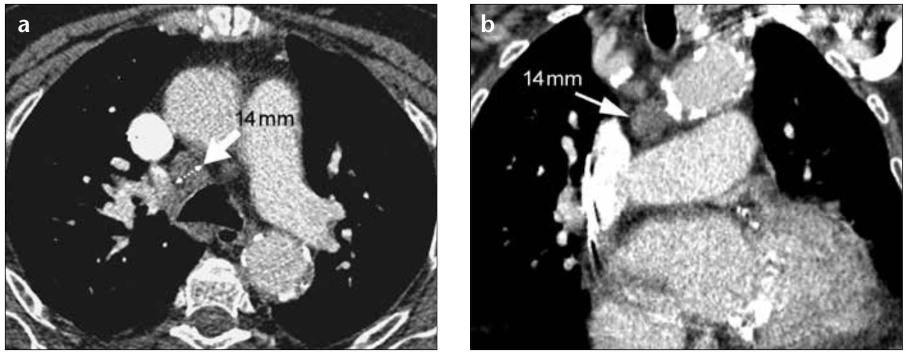

Figure 2. a, b. A 61-year-old man with a history of coronary artery bypass grafts. Axial **(a)** and coronal **(b)** reformats demonstrated a 14-mm lymph node in station 4R (*arrows*). No other lymphadenopathy was identified. History of cardiac failure or lung parenchymal abnormality was not present. No history of neoplasm was identified. Note the nonbony union of the sternum after sternotomy **(a)**.

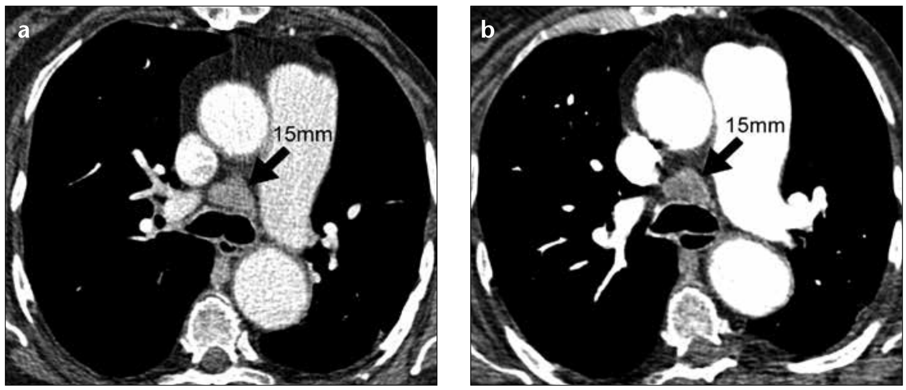

Figure 3. a, b. A 72-year-old man with a history of coronary artery bypass grafts. Axial CT in 2006 **(a)** demonstrated a 15-mm lymph node in station 4R *(arrows)*. No other lymphadenopathy was identified. No underlying etiology was elucidated. Axial CT in 2010 **(b)** demonstrated no change in the mediastinal lymphadenopathy over a four-year period.

monary edema (n=13), surgery within three months of the CT (n=6), inadequate scan range (n=6), chronic interstitial lung disease (n=12), connective tissue disease with fibrosis (n=1), and immunosuppression (n=1).

Indications for sternotomy included CABG (n=54), valve replacement (n=17), CABG and valve replacement (n=4), Fontan procedure during childhood (n=1), annuloplasty (n=1), thymoma excision (n=1; surgical-pathological analysis confirmed no evidence of malignancy in the resection specimen), aortic arch repair (n=1), bilateral pleurodesis (n=1), and previous atrial septal defect repair (n=2). Twenty two patients had a single graft, 16 had two, 17 had three, and three patients had four grafts. Fifty-three patients had a left internal mammary arterial graft to left anterior descending coronary artery, 38 had a saphenous vein graft to an obtuse marginal branch, 37 had a saphenous vein graft to the right coronary artery, and 17 had a saphenous vein graft to a diagonal branch.

Mediastinal and/or hilar enlarged LNs were identified in 36 patients (43.9%) (Figs. 2 and 3, Table). In contrast, none of the twenty control cases exhibited enlarged nodes (mean lymph node size, 6.0±2.0 mm). Mean lymph node enlargement was mild (13.0±2.0 mm) and only four patients (10%) had LNs >15 mm. Enlargement of the nodes in station 4R was most common (n=18, 50%; mean size, 13.1±2.0 mm) followed by those of station 7 (n=16, 44%; mean size, 12.3±2.2 mm). The majority of patients had one (n=20, 56%) or two (n=12, 33%) nodal stations with enlarged LNs, and only one patient had four involved lymph node stations.

Correlative analysis did not reveal patients' age, gender, type of cardiac surgery, number of CABGs or valves as having a significant relationship with the presence or absence of mediastinal or hilar enlarged LNs for the entire study cohort or the subgroup with enlarged LNs. Furthermore, regression analysis did not reveal a significant association between enlarged lymph nodes and any clinical or surgical parameter. The serial CT scans of 15 patients with enlarged LNs with a mean follow-up time of 21 months exhibited no change in any nodal station during follow-up ($P > 0.05$).

Discussion

The major finding of this study is that approximately 44% of patients with a history of open cardiac surgery demonstrate mildly enlarged mediastinal and/or hilar LNs that typically involve 1–2 lymph node stations. Serial scans characteristically show no change in the size of the enlarged nodes over time. Patients without a history of cardiac surgery do not present with nodal enlargement on CT scans.

We have anecdotally observed that many patients with a history of cardiac surgery demonstrate low-volume enlarged LNs on chest CT scans without any underlying identifiable cause. In these cases, the etiology for the enlarged LNs is unknown. Patient and surgical characteristics such as number of grafts and graft/valve combinations did not seem predictive, nor did they predict which nodal stations would be involved. Several potential explanations exist for these persistent enlarged nodes in cardiac surgery patients. For example, because open cardiac surgery involves a sternotomy, the mediastinal structures are potentially exposed to atmospheric contaminants, which may cause node enlargement. However, typically, reactive LNs naturally regress over time, and open surgery to other parts of the body does not usually result in persistent enlarged nodes. A second explanation might be that surgical materials such as talc, sutures, or surgical clips may invoke a reaction within adjacent draining nodes. However, not all patients who had undergone sternotomy had enlarged LNs, and no significant correlation was identified between the number of grafts and the number of enlarged

Table. Location and dimensions of mediastinal and/or hilar lymphadenopathy in patients with previous sternotomy

Nodal station	Number of patients						Nodal size (mean±SD, mm)
	Controls	CABG	Prosthetic valve	CABG+prosthetic valve	Other	Total (%)	
1	-	-	-	-	-	-	-
2	-	5	1	-	-	6 (7)	11.3±0.8
3	-	2	1	-	-	3 (4)	11.3±0.6
4R	-	11	6	-	1	18 (22)	13.1±2.0
4L	-	3	3	-	-	6 (7)	13.2 2.4
5	-	-	-	-	-	-	-
6	-	-	-	-	-	-	-
7	-	10	3	1	2	16 (20)	12.3±2.2
8	-	-	-	-	-	-	-
9	-	-	-	-	-	-	-
10	-	4	3	-	-	7 (9)	12.6±1.3
11	-	-	-	1	-	1 (1)	14.0
12–14	-	-	-	-	-	-	-

CABG, coronary artery bypass grafts; SD, standard deviation.
Nodal stations are referenced from the 7th edition TNM staging system for lung cancer (10).

LNs. Poststernotomy mediastinitis is an unlikely cause, since it occurs in only 3% of cases, considerably lower than the prevalence of enlarged LNs in our study, and it is typically associated with a high morbidity and mortality (12), which was not observed among the patients in our study. Also, many cardiac patients demonstrate lymphadenopathy during acute exacerbations of left-sided heart failure (13). However, none of the patients in our cohort demonstrated additional signs of heart failure, such as septal lines or ground-glass opacities (14), as we specifically excluded all patients with such findings.

Preoperative CT scans were not available for analysis, since many patients had their cardiac surgery many years before their CT scan. This was expected, as the predominant imaging method for CABG patients is invasive coronary angiography. Nonetheless, it is possible that some of our patients had preoperative enlarged LNs, although we believe this is unlikely due to the high prevalence (44%) we observed in this study. In addition, in a previous study of 589 patients that underwent CT pulmonary angiography for suspected pulmonary embolism, incidental mediastinal and/or hilar lymphadenopathy was detected in only 11%–14% of patients (15). Similarly, in a coronary CT study by Onuma et al. (16), incidental mediastinal or hilar lymphadenopathy was seen in only three (0.6%) of 503 patients. As a result, we believe that the 44% prevalence of enlarged nodes in patients with previous sternotomy is not due to pre-existing enlargement.

Our findings have significant implications with regards to nodal sampling when enlarged nodes are observed in CT scans. Surgical nodal sampling for enlarged LNs is known to be more challenging in patients with a history of sternotomy, and many thoracic surgeons regard previous sternotomy as a relative contraindication to nodal sampling (17). Mediastinal fibrosis and adhesions can lead to limited surgical assessment and sampling of lymph nodes, while limited visualisation can lead to inadvertent biopsy of vascular structures. Furthermore, due to the opening of the pericardial sac, grafts may be damaged during mediastinoscopy, particularly for patients with left internal mammary artery grafts undergoing left anterior mediastinostomy (18). Endobronchial US is a more attractive option than surgery for nodal sampling in patients with a history of sternotomy, since it is less invasive and has the ability to access nodes that are inaccessible with mediastinoscopy, such as at the subcarinal station (19). However, its diagnostic accuracy is also considered to be reduced following previous mediastinal surgery (20). As a result, both surgical nodal sampling and endobronchial US are procedures that should be used conservatively.

It is precisely for this reason that knowledge of the association between previous sternotomy and low-volume enlarged LNs is important. As long as the lymph node enlargement is mild (<15 mm) and only 1–2 nodal stations are involved, a more conservative approach can be taken before surgical nodal sampling or endobronchial US are used. For example, in our institution, we apply a surveillance protocol when such enlarged nodes are identified on initial chest CT scans in patients with a history of sternotomy: we proceed with a repeat chest CT in three months and thereafter at every six months for the following two years. If node enlargement remains stable during this time, we conclude that the enlarged nodes are benign and the patients no longer undergo imaging. Although this surveillance protocol incurs some imaging costs, the overall savings in avoiding nodal sampling is substantial. Most importantly, this protocol prevents patients from undergoing unnecessary procedures that may result in morbidity.

Although several CT studies reviewed poststernotomy node enlargement of the mediastinum, to our knowledge, this is the first study that assessed the prevalence of enlarged LNs following sternotomy. For instance, Kumar et al. (21) assessed 22 patients with enlarged LNs with mediastinoscopy who had undergone previous sternotomy for cardiac surgery. All patients were being tested for primary lung carcinoma. In 12 patients, despite thorough nodal sampling, histopathological analyses did not find any evidence of cancer, which correlates with our observation that patients may simply demonstrate enlarged LNs after sternotomy.

Our study has several limitations. In this retrospective study, we did not have any proof, such as biopsy sample analysis, that the enlarged LNs were in fact benign. However, none of the patients for whom serial scanning was available exhibited any changes in their enlarged LNs over time. We did not assess inter-reader variability for nodal measurements, although this has been previously shown to be low for CT scan readings (22). Finally, we were unable to ascertain the exact time interval between time of surgery and chest CT in this cohort, because many patients had undergone their surgery several decades before their chest CT and lacked adequate medical records.

In conclusion, mildly enlarged LNs in 1–2 nodal stations are observed in the chest CT scans of almost half of the patients with a history of sternotomy. Taking this into consideration, monitoring enlarged LNs in poststernotomy patients can prevent unnecessary procedures for nodal sampling in a cost-effective manner.

Conflict of interest disclosure

The authors declared no conflicts of interest.

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