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FULL PAPER

Incidental findings in the skeletal musculature on computed tomography

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Objective: The purpose of this study was to analyze intramuscular incidental findings identified on CT in a large patient cohort.

Methods: In the time period from 2010 to 2015, a total of 44,794 patients with several diagnoses were investigated by CT. Only those patients who underwent body CT including the neck, thorax, abdomen and pelvic regions after the i.v. application of a contrast medium were involved in the study. There were 4085 patients. On further analysis, only patients with intramuscular findings (IFs) incidentally detected on CT were included. Osseous or soft-tissue lesions with invasion into the musculature were excluded from the study. Patients with known or clinically suspicious muscle disorders were also excluded. Overall, 639 (15.64% of the 4085 analyzed cases) patients, 253 females and 386 males, with mean age 72.43 ± 12.02 years, were identified. Collected data were evaluated by means of descriptive statistics.

Results: In the 639 patients, 917 IFs were identified. More often, several benign disorders were diagnosed ($n = 803$, 87.6%). There were hernias (33.5%), atrophy of different muscles (22%), lipomas (21%), intramuscular calcifications (8.7%), bursitis (1.2%) and intramuscular bleeding (1.1%). Malignant IFs ($n = 114$, 12.4%) included intramuscular metastases (11.9%) and lymphomas (0.6%). Most frequently, the identified IFs were localized in the abdominal wall musculature, paravertebral and gluteal muscles. In 657 cases (71.6% of all IFs), the identified muscle findings were not diagnosed by the radiologist who initially assessed the investigation.

Conclusion: CT can detect different incidental disorders within the skeletal musculature. Most of them were benign. However, malignant lesions can also occur. Therefore, skeletal muscles should be carefully evaluated on CT performed for other reasons.

Advances in knowledge: IFs occur in 15.6% of CT investigations. Benign findings represent 87.6% and malignant lesions can be identified in 12.4%.

INTRODUCTION

Incidental findings on imaging represent findings that are not related to the scope of the ordered investigation.¹ They are common and can also be more relevant than the primary disease indicated in the investigation.^{1–3} For example, there were different malignant lesions detected in patients on CT performed for transcatheter aortic valve replacement.⁴ Other examples were urgent cardiovascular findings such as massive pulmonary embolism or aortic dissection incidentally identified in staging investigations in patients with oncological diseases.^{5,6}

Previously, several incidental findings were categorized according their clinical relevance as follows: Group “1”, normal findings or anatomic variant; Group “2”, clinically unimportant findings; Group “3”, likely unimportant findings; and Group “4”, potentially important findings.⁷ Most studies that analyzed incidental findings on imaging, especially on CT, focused on the prevalence of several

incidentally detected malignancies or clinically relevant findings.^{2–6,8–10} To the best of our knowledge, there were no previous reports regarding incidental findings in the skeletal musculature. However, it is the largest region of the body and may contain different findings.

Therefore, the purpose of this study was to analyze intramuscular incidental findings identified on CT in a large patient cohort.

METHODS AND MATERIALS

This study was approved by the institutional ethics board.

Patients

In the time period from 2010 to 2015, a total of 44,794 patients with several diagnoses were investigated by CT. On further analysis, only those patients who underwent body CT including the neck, thorax, abdomen and pelvic regions after the i.v. application of a contrast

Figure 1. Data acquisition.

medium were involved (Figure 1). Patients with other CT investigations, such as isolated thoracic or abdominal CTs, CT of the head and/or neck, extremities etc., were excluded from the study. Angiographic CT investigations and CT investigations without the i.v. administration of a contrast medium were also excluded. Overall, 4085 patients who met the inclusion criteria were identified. All 4085 CTs were analyzed retrospectively by three radiologists (DS, AKJ and AS with 9, 1 and 14 years' general radiological experience) by using the electronic picture archive (Centricity® PACS; GE Medical Systems, Milwaukee, WI). In detail, two radiologists (DS and AKJ) analyzed the images together and presented all identified intramuscular findings (IFs) to the senior radiologist (AS). All IFs were described/categorized in consensus by the investigators. Only patients with IFs incidentally detected on CT were included in the study. Osseous or soft-tissue lesions with invasion into the musculature were excluded from the study. Furthermore, patients with known or clinically suspicious muscle disorders were also excluded. IFs were found in 639 patients (15.64% of all analyzed 4085 cases). There were 253 females and 386 males with a mean age of 72.43 ± 12.02 years; median age, 75 years.

CT

In all patients, CT (Somatom Sensation 64; Siemens, Erlangen, Germany) of the cervical, thoracic and abdominopelvic regions was performed. In all cases, 1.5 ml of an iodinated i.v. contrast medium (Solustrast®; Bracco Altana GmbH, Konstanz, Germany) per body mass was given at a rate of $1.5\text{--}3.5\text{ ml s}^{-1}$ by a power injector (Medtron GmbH, Germany), with a scan delay of 60–90 s after onset of injection. Imaging parameters were as follows: tube voltage: 120 kVp, tube current–time product: 150–300 mAs, slice thickness: 0.6–1 mm.

Statistical analysis

For statistical analysis, the SPSS® (IBM Corp., New York, NY; formerly SPSS Inc., Chicago, IL) statistical software package was used. Collected data were evaluated by means of descriptive statistics. Continuous variables were expressed as mean $\pm$ standard deviation and categorical variables as percentages.

RESULTS

In the 639 patients, 917 IFs were identified (Table 1). In 481 patients, 1 IF was detected, in 94 cases 2 IFs, in 25 cases 3 IFs and in the remaining 39 patients, >3 IFs were found. More often, several benign disorders were diagnosed ($n = 803$, 87.6%). There were hernias, atrophy of different muscles, intramuscular calcifications, lipomas, bursitis and intramuscular bleeding in the decreasing

order of frequency (Table 1). Malignant IFs ($n = 114$, 12.4%) included intramuscular metastases and lymphomas (Table 1). Most frequently, the identified IFs were localized in the abdominal wall musculature, paravertebral and gluteal muscles (Table 2).

Muscle hernias were found in 33.5%. All hernias were localized in the abdominal wall (diastasis of the rectus abdominis or/and obliquus abdominis muscle) (Figure 2a). Most identified hernias contained mesenteric fat (73.6%).

Atrophy of isolated muscles or muscle groups was identified in 22% of all IFs (Figure 2b). The following muscle groups were affected: abdominal wall musculature (34.6%), lower extremity muscles (17.3%), paravertebral muscles (14.4%), gluteal muscles (13.4%), upper extremity muscles (12.4%), iliopsoas muscle (6.9%) and thoracic wall muscles (1%).

Muscle lipomas represented 21% of all IFs (Figure 2c). Their size varied from 5 mm to 90 mm. Lipomas were found in different muscles: paravertebral musculature (27.5%), lower extremity muscles (24.3%), upper extremity muscles (14%), abdominal wall muscles (13.5%), gluteal musculature (13%), thoracic wall muscles (4.1%) and iliopsoas muscle (3.6%).

Intramuscular calcifications were identified in 8.7% IFs. Most frequently, they were localized in the gluteal musculature (65%).

Table 1. Identified Intramuscular findings (IFs)

Intramuscular findings	<i>n</i>	%
Benign IF		
Hernia	307	33.5
Atrophy	202	22
Lipoma	193	21
Calcifications	80	8.7
Bursitis	12	1.3
Bleeding	9	1.0
Malignant IF		
Metastases	109	11.9
Lymphoma	5	0.6
Total	917	100

Table 2. Localizations of intramuscular findings

Muscle groups	<i>n</i>	%
Abdominal wall muscles	430	46.9
Paravertebral muscles	129	14.1
Gluteal musculature	126	13.7
Lower extremity muscles	99	10.8
Upper extremity muscles	66	7.2
Iliopsoas muscle	46	5
Thoracic wall muscles	21	2.3
Total	917	100

Other localizations were rare: lower and upper extremity muscles (17.5%), paravertebral musculature (10%), abdominal wall muscles (5%) and iliopsoas muscle (2.5%).

Bursitis was diagnosed in 1.3% of the identified findings. There were bursitis subscapularis ($n = 3$) and bursitis of the iliopsoas muscle ($n = 8$) (Figure 2d).

In 1.0% of the IFs, intramuscular bleeding was detected. The localizations of incidentally detected haematomas were

abdominal wall musculature ($n = 4$), iliopsoas muscles ($n = 3$) and lower extremity muscles ($n = 3$).

Intramuscular metastases represented 11.9% of all findings (Figure 3a,b). All of the patients with muscle metastases also had other metastases, such as liver and/or lymph nodes, lung and/or bone metastatic lesions. Intramuscular metastases were localized in the following muscle groups: paravertebral muscles (43.2%), gluteal musculature (16.5%), abdominal wall muscles (12.8%), iliopsoas muscle (11%), lower and upper extremity muscles (11%) and thoracic wall muscles (5.5%).

In six patients, muscle metastases were histologically proven. In other cases, the diagnosis was made because of follow-up and the presence of other metastatic lesions.

Involvement of muscles in lymphoma was identified in 0.6% of all IFs (Figure 2c,d). The lymphomas affected the intercostal muscle ($n = 1$), piriformis muscle ($n = 1$), iliopsoas muscle ($n = 1$), paravertebral musculature ($n = 1$) and abdominal wall musculature ($n = 1$). In all cases, the diagnosis of muscle lymphoma was confirmed by histopathology.

All identified incidental IFs were categorized according to Lumbreras et al² as follows (Table 3): major or clinically relevant (12.4%), moderate (11.1%) and clinically not relevant (76.5%).

Figure 2. Benign intramuscular findings incidentally identified on CT: (a) atrophy of the left abdominal wall muscles (arrow); (b) hernia of the abdominal wall (arrow); (c) lipoma within the right gluteal musculature (arrow); (d) bursitis iliopsoas (arrow). All of the lesions were discovered retrospectively.

Figure 3. Malignant intramuscular findings incidentally identified on CT: (a) intramuscular metastasis in the right deltoid muscle (arrow)—the lesion was not diagnosed. In this case, other multiple metastases were also present (not shown). (b) Metastasis in the left gluteal musculature (arrow): the lesion was diagnosed at the time of the CT investigation. (c) Enlargement of the left piriformis muscle (arrow)—histological examination confirmed the diagnosis of a diffuse large B-cell lymphoma. (d) Histologically proven diffuse large B-cell lymphoma within the enlarged left rectus abdominis muscle (arrow): the lesion was diagnosed at the time of the CT investigation.

In 657 cases (71.6% of all IFs), the identified muscle findings were not diagnosed by the radiologist who initially assessed the investigation, since this was discovered retrospectively (Table 4).

Table 3. Categorization of intramuscular findings (IFs)

Intramuscular findings	<i>n</i>	%
Major IF	114	12.4
Metastases	109	
Lymphoma	5	
Moderate IF	102	11.1
Bowel-containing hernias	81	
Bursitis	12	
Bleeding	9	
Minor IF	701	76.5
Calcifications	80	
Lipoma	193	
Fat-containing hernias	226	
Atrophy	202	

Most frequently, several benign muscle disorders were under-diagnosed (79.1% of all benign IFs). Most malignant IFs (80.7%) were diagnosed at the time of CT investigation.

DISCUSSION

According to the literature, incidental findings are a common phenomenon on imaging, especially on CT.^{1–3} Their prevalence accounted for approximately 70% of all investigations.³ Furthermore, the number of incidental findings varied from 2.8 to 3.2 per patient investigated.^{3,9} Most frequently, different malignant lesions and cardiovascular findings incidentally detected on CT have been reported.^{2,5,6,8–10} Although skeletal muscles represent approximately 50% of total body mass, IFs on imaging investigations have been not reported previously.

For example, Lumbreras *et al*² published a large systematic review regarding incidental findings in different diagnostic tests. Overall, 44 articles were included in the review.² The authors classified all findings into major or clinically relevant, moderate or possible clinically relevant and minor or clinically not relevant.² However, possible IFs were not described in this work and therefore not categorized.² In addition, Furtado *et al*,³ who analyzed 1192 patients investigated by using whole-body CT, also did not describe IFs.

Table 4. Diagnosed and non-diagnosed intramuscular findings (IFs)

Intramuscular findings	Diagnosed IF	Non-diagnosed IF
Benign IF (<i>n</i> = 803)	168 (20.9%)	635 (79.1%)
Hernia	113	194
Atrophy	16	186
Lipoma	19	174
Calcifications	8	72
Bursitis	6	6
Bleeding	6	3
Malignant IF (<i>n</i> = 114)	92 (80.7%)	22 (19.3%)
Metastases	88	21
Lymphoma	4	1

Our study showed that CT scans can identify several incidental findings within the skeletal musculature. Most of them were different benign muscle disorders, such as atrophy, calcifications or lipomas, which were not clinically relevant. However, some incidentally detected benign disorders, such as bursitis or intramuscular haematomas, were possibly relevant and, as reported previously, may be misinterpreted on CT.¹¹ Therefore, it is important for radiologists to know that the skeletal musculature can contain some benign lesions, which have typical radiological patterns. The present analysis also provided their typical localizations.

Furthermore, 12.4% of the IFs were malignant lesions. There were intramuscular metastases and involvement of muscles in lymphoma. As reported previously, muscle metastases occurred with a prevalence ranging from 0.03% to 5.6%.^{11–13} They can manifest with different patterns on imaging.^{11–14} Furthermore, according to the literature, most of them were clinically silent and were found incidentally during staging investigations.¹¹ It has been shown that more often, muscle metastases arose from urogenital tumours, malignant melanoma and gastrointestinal malignancies.¹¹ Our results confirmed these data. In our study, all patients also had other systemic metastases. However, muscle metastases can be an isolated manifestation of metastatic disease.^{11,12}

Intramuscular manifestation of lymphoma is very rare.¹⁵ According to previous reports, the frequency of muscle lymphoma varied from 0.1% to 1.4% of all extranodal lymphomas

and from 1.2% to 2.0% of all cases with malignant muscle tumours.^{15–17} Intramuscular lymphomas can present as solid muscle lesions or as diffuse muscle enlargement.^{15–18}

The present study showed that in most cases (71.6%), IFs were not diagnosed at the time of CT investigations. Therefore, it is important to check the skeletal musculature in radiological investigations.

According to the literature, other intramuscular lesions can also be identified incidentally on radiological tests.^{19,20} For example, several anatomical variants including the absence of muscles or accessory muscles have been described.^{19,20} Kobayashi et al²⁰ reported two cases of the sternalis muscle presenting as an incidental finding on chest CT.

Furthermore, different intramuscular tumours can be found. Yoshida et al²¹ described a case of intramuscular tumour incidentally detected on positron emission tomography. In addition, there were cases of different muscle parasitic diseases, which were also incidentally identified on CT.^{22,23}

In conclusion, the present study showed that CT can detect different incidental disorders within the skeletal musculature. Most of them were benign. However, malignant lesions can also occur. Therefore, skeletal muscles should be carefully evaluated on CT performed for other reasons.

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