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CT imaging features of skeletal muscle metastasis

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AIM: To define the computed tomography (CT) features common in skeletal muscle metastases and their prevalence and to identify the most commonly associated primary malignancy and the most common muscle groups in which skeletal muscle metastases are found.

METHODS AND MATERIALS: Institutional review board (IRB) waiver for informed consent was obtained. A retrospective review was conducted of CT examinations from a single, large, academic centre picture archiving and communication system (PACS) database, performed from August 2009 to July 2013. All 10,426 examinations and 8,524 unique patients reviewed had a confirmed diagnosis of malignancy. The CT reports were screened manually to identify disease involving the skeletal muscles. Images of the 60 initial studies identified were then reviewed. Cases that showed direct invasion of the tumour into the skeletal muscles, and follow-up studies of the same patient were excluded. The 27 included cases were classified under five distinct patterns.

RESULTS: In the present study, the prevalence for skeletal muscle metastasis was 0.33% across all malignancies. The most common primary involved was breast cancer (25%). The most common pattern was focal intramuscular mass with homogeneous contrast enhancement. The most common sites of skeletal muscle metastasis were in the abdomen (43%) and thorax (33%) musculature.

CONCLUSION: Breast cancer was the most commonly associated primary malignancy and a focal, homogeneously enhancing intramuscular mass was the most common presentation. Although skeletal muscle metastasis remains a rare entity, its incidence rate should increase with the increased usage of whole-body PET CT for cancer staging.

Introduction

The present study was undertaken to review cases of skeletal muscle metastasis (SMM) at Tan Tock Seng Hospital to determine the frequency of the disease and to analyse the radiological features.

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Methods and materials

Institutional review board (IRB) waiver for informed consent was obtained. A retrospective review was conducted of computed tomography (CT) examinations from a single, large, academic centre picture archiving and communication system (PACS) database, over a 3.5 year period, spanning from August 2009 to July 2013. All patients with a confirmed diagnosis of malignancy, who had undergone a CT study at Tan Tock Seng Hospital, were reviewed. A total of 10,426 examinations, and 8,524 unique patients were identified. The CT reports were screened manually to identify disease involving the skeletal muscles. Images of the studies identified were reviewed. Cases that showed direct invasion of the tumour into the skeletal muscles, and follow-up studies of the same patient were excluded. The studies were classified into five distinct patterns, as first described by Surov *et al.*[1]: Type I: focal intramuscular mass with homogeneous contrast enhancement; Type II: abscess-like intramuscular lesion; Type III: diffuse metastatic muscle infiltration; Type IV: multifocal intramuscular calcification; and Type V: intramuscular bleeding.

Results

A total of 10,426 reports of confirmed cancer cases were reviewed, with 8,524 unique patients. Of these, 60 were initially identified. Subsequently, the images were analysed and total of 27 cases were included in the study. Thrity-three studies were excluded because these were either repeat examinations of the same patient or showed evidence of direct invasion.

The majority of the patients are Chinese, which contribute to 22 cases with the remaining patients comprising four Malay patients and one Indian patient. There are 16 female and 11 male patients with ages ranging from 41–80 years old.

The distribution of cases based on the primary malignancy is illustrated in Table 1. The most common malignancies found were breast (25%), colorectal (22%) and lung (11%). Great care was taken when examining the breast and lung cases to exclude direct invasion into the chest wall. The distribution of cases based on location of metastasis is illustrated in Table 2. An individual count was added for each region affected in a case involving multiple foci. The most common site of metastasis found was in the abdomen (43%) and thorax (33%), and the most common muscles involved were the rectus abdominis (seven cases), psoas (four cases), and sternocleidomastoid (three cases). A further breakdown of distribution based on the primary tumour showed a higher propensity for malignancies to affect muscles in the same anatomical region. Appearances on contrast-enhanced CT varied and are summarised in Table 3. Type 1 was the most prevalent (55%), followed by Type 3 (30%).

Table 1
Distribution of cases by type of primary malignancy

Primary malignancy	No. of cases
Breast carcinoma	7
Colorectal carcinoma	6
Lung carcinoma	3
Synovial sarcoma	2
Stomach cancer	1
Nasopharyngeal carcinoma	1
Thymic carcinoma	1
Transitional cell carcinoma	1
Chondrosarcoma	1
Squamous cell carcinoma of the mandible	1
Metastasis of unknown primary	1
Pancreatic cancer	1
Multiple Myeloma	1

Discussion

Skeletal muscle is not a common area when listing sites for cancer metastasis, despite being the main constituent of body mass and receiving a significant blood supply. There are various theories postulated to explain this rarity. One theory involves the natural relative acidity of striated muscles .[2] Lactic acid is a signal for anoxia, and stimulates blood vessel growth. This acidity may give a natural resistance to neo-vascularisation of the tumour as the blood vessels in the region have a greater tolerance to an anoxic stimulus from the tumour.[2] Another theory describes the effect of motion and electrical stimulation on cancer cells.[3] The study showed that cancer cell survival is greatest in denervated, then non-contracting muscle, and least in electrically stimulated muscle. A third theory found that muscle cells produce a low molecular weight factor that is highly selective for tumour cells *in vitro* and *in vivo*.[4] The factor was found to be neither species nor tumour specific.

The bulk of the literature regarding this topic consists of case reports and case series. In a large literature review by Haygood *et al.* of 264 cases and 151 articles,[5] SMM has been reported in malignancies involving almost all parts of the body. Although the reported case numbers are low, and reported incidence described as 1.8%,[6] autopsy studies cite an incidence of up to 16–17.5%[7,8] in two particular studies. A few series express that a painful mass was most commonly associated with the diagnosis of SMM[5,9,10]; however, other studies,[1,11] and the discrepancy between reported cases and autopsy incidence, suggest that most of these lesions likely bear no symptoms. Routine oncological imaging using CT often excludes the limbs where the bulk of skeletal muscle is present. Most large-scale reports thus far use retrospective analysis of CT examinations pulled from an institutional database.[1,5,11] Limb imaging is usually only obtained if

Table 2
Distribution of cases by location of muscle metastasis

Location of metastasis	No. of cases
Head and neck	5
Thorax (including trapezius and rotator cuffs)	10
Upper limb (including deltoid)	1
Abdomen (including psoas muscle)	13
Lower limb	1

Table 3
Distribution of cases by radiological appearance on computed tomography (CT)

CT features of metastasis	No. of cases
Type 1 (focal intramuscular mass with homogeneous contrast enhancement.)	15
Type 2 (abscess-like intramuscular lesion)	5
Type 3 (diffuse metastatic muscle infiltration.)	8
Type 4 (multifocal intramuscular calcification)	1
Type 5 (intramuscular bleeding)	2

symptoms are present. This systematic error likely results in a significant portion of muscle metastasis going undiscovered. With increasing use of whole-body positron-emission tomography (PET) for oncological staging, it is likely that the detection rate for SMM will increase.

It is important to distinguish SMM from primary sarcomas as management and prognosis differs markedly; however, in actual clinical practice, biopsy of metastases is usually not clinically justifiable. Most metastases of any type go without tissue diagnosis.[5] For most of the present cases, diagnosis was made based on the presence of other foci of metastatic disease, or evidence of disease progression during the follow-up CT examination. In five cases where the diagnosis was suspect, tissue diagnosis was obtained for confirmation.

In the present study, the prevalence of SMM was approximately 0.33% (27 identified cases out of 8,524 patients). These were mainly detected during routine imaging follow-up for confirmed cancer patients.

The five different radiological appearances described by Surov *et al.*[1] were used to classify the CT appearance. Out of these, Type I (Fig 1) had the highest incidence (55%), followed by Type III (Fig 3; 30%) and Type II (Fig 2; 19%). Surov *et al.* had similar rates for Type I (52.5%) but differed for Type II (32.5%) and Type III (8.8%).[1] Other studies reported that rim-enhancing with central hypo-attenuation (Type II) was the most common[11] pattern encountered. In the present study, the only case that presented with a Type IV (Fig 4) pattern was a patient who had synovial carcinoma.

Figure 2 (a) Metastasis to the right illiopsoas, with (b) intramuscular rimenhancing collection (Type 2). Primary malignancy was rectal adenocarcinoma. Aspiration of the collection with biopsy confirmed that this was due to metastasis.

The most common primary malignancy encountered in the present study was breast carcinoma (25%), followed by colorectal carcinoma (22%). Other studies reported lung[5,11] and genitourinary[1] as the most common primary malignancies. Tan Tock Seng Hospital is one of the main referral centres for breast cancer and breast screening in Singapore. The present results may be confounded by the larger number of scans performed on patients with breast carcinoma. Studies thus far have been mostly retrospective, and had a small cohort. Differences in composition of the initial

Figure 1 Type 1 skeletal muscle metastasis. Focal intramuscular masses in the left subscapularis and infraspinatus with homogeneous contrast enhancement. Primary malignancy was a right breast adenocarcinoma.

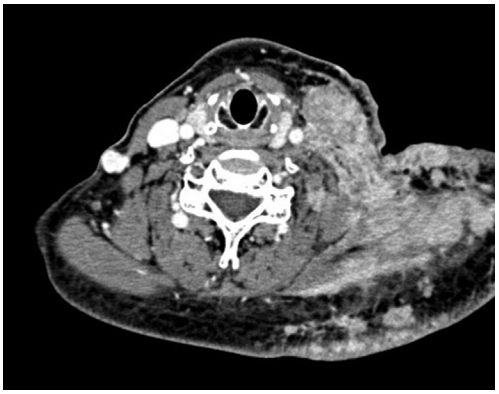

Figure 3 Diffuse infiltration and enhancement of the left sternocleidomastoid and trapezius muscles (type 3). Skin involvement with enhancing nodules is also noted. Primary cancer was a left breast adenocarcinoma.

Figure 4 Metastasis to the right illiopsoas from a synovial carcinoma primary. (a) Intramuscular calcification (Type 4) is seen in the right psoas. (b) Haematoma (Type 5) was seen in the right illiacus muscle.

sample pool may be a confounding factor on the most common primary malignancy.

The most common sites for metastasis were the thorax and abdomen, similar to other studies.[1,5] Increased incidence in these areas may reflect the natural inclusion of these areas during the imaging protocol itself. The most common muscle affected was the rectus abdominis (n=6). Other studies listed the psoas, paraveretebral, and gluteal muscles as more common sites of metastasis.[1] In the present cases, SMM tended to be discovered within the same anatomical region as the primary tumour itself. Various theories for the mechanism of metastasis are reported, including arterial emboli of tumour cells[7], retrograde flow through the venous plexus[12], lymphatics through intramuscular aberrant lymph nodes[1] and perineural spread[13]. Although haematogenous spread is the currently favoured theory, lymphatic spread may account for the regional metastatic pattern. SMM was also reported to be more common when other sites of metastasis have occurred.[5,11]

In conclusion, SMM has a low incidence rate of 0.33%. It can occur with any tumour, but most of the cases in the present study were associated with breast cancer. It is most commonly seen incidentally on follow-up imaging, appearing as a homogeneously enhancing intra-muscular mass. The incidence should increase with the increasing adoption of combined PET/CT.

Conflict of interest

The authors declare no conflict of interest.

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