Int J Clin Exp Med 2015;8(9):16745-16755
www.ijcem.com /ISSN:1940-5901/IJCEM0008226

Case Report

Computed tomography appearance of inflammatory myofibroblastic tumor in the abdomen: CT features and pathologic correlation

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Received March 19, 2015; Accepted September 6, 2015; Epub September 15, 2015; Published September 30, 2015

Abstract: Objective: To evaluate CT findings of abdominal inflammatory myofibroblastic tumor (IMT) and the relationship with morphological character. Materials and Methods: CT examinations and pathological findings of ten intra-abdominal IMTs were retrospectively analyzed. The histopathological characteristics of the IMTs were confirmed by two pathologists and two radiologists evaluated CT findings of the lesion, with emphasis on the imaging features compared with the corresponding histopathology. Results: The most common imaging characteristics were presence of heterogeneity, all tumors showed varying degrees of contrast enhancement. Two major different CT patterns were individualized. In type one, the tumor had a distinct boundary without a lobular appearance and displayed hypo-enhanced enhancement after administration of contrast in correlated with the mainly histopathologic findings of spindle cells myxoid and hypocellular fibrous (6/10; 60%). In type two, the lesions exhibited indistinct boundaries or complete capsule, ill-defined growth patterns or low intralesional attenuation with marked heterogeneous or circumferential enhancement, which correlated well with the presence of abundance of micromodule and inflammatory cell infiltration (4/10; 40%). Conclusions: Two major different contrast enhancement CT patterns were individualized can help to determine the relationships with histopathologic findings, while cannot be reliably differentiated from other solid lesions based solely on the CT appearance, combined with diagnostic biopsy may facilitate to achieve a correct diagnosis and treatment.

Keywords: Inflammatory myofibroblastic tumor, abdomen, computed tomography, histology

Introduction

Inflammatory myofibroblastic tumor is a rare mesenchymal neoplasm with uncertain etiology. Originally, it was termed "inflammatory pseudotumor", "postoperative spindle cell nodule", inflammatory myofibrohistiocytic proliferation" [1]. Subsequently, further studies have identified its true nature as a neoplasm which may recur and rarely metastasize. Its classical features were spindle cells proliferation intermixed with inflammatory cells which were thought to reflect diverse entities [2]. Moreover, it was classified as a tumor which has a tendency for local recurrence and a risk of distant metastasis malignant transformation according to World Health Organization classification. IMT in the abdomen can occur at any location including the stomach, intestine, mesentery, peritoneum, retroperitoneum, pancreas, liver, and so on. The purpose of our retrospective study was to bring forth some evidence that different enhanced CT imaging may be derived from the subtype of histological component and delineated the variable clinicopathologic features and corresponding CT imaging, in effort to establish an appropriate CT diagnosis approach with the use of surgical and histopathological findings as the reference standard.

Materials and methods

We retrospectively reviewed ten consecutive IMT patients and obtained informed consent

Table 1. Clinical, demographic and laboratory data of abdominal IMT

NO.	Sex/Age (years)	Symptoms/signs	Location	Maximum Diameter (cm)	Laboratory Abnormalities
1	F/18	Stomachache	Mesentery	3.5	Normal
2	M/14	Epigastric discomfort	Omentum Stomach	4.5	Anemia, ESR↑
3	M/23	Pain	Colon	11	Leukocytosis, ESR↑, CRP↑
4	M/12	Vomiting	Mesentery	6.5	ESR↑
5	M/38	Abdominal distention	Mesentery Intestines	6.5, 9	Anemia, ESR↑
6	M/54	Incidentally detected	Intestines	7	Hyperglobulinemia, CRP↑
7	F/18	Fever	Colon retroperitoneum	12.5	eESR↑, Anemia, Leukocytosis
8	F/16	Vomiting	Intestines	7.5	ESR↑
9	M/24	Pain	Intestines	15	ESR↑
10	F/26	Fever Anemia,	Behind liver	9	CRP↑, Leukocytosis, ESR↑

F: Female, M: Male, Pain: Abdominal pain, ESR↑: Elevated erythrocyte sedimentation rate, CRP↑: Elevated C-reactive protein.

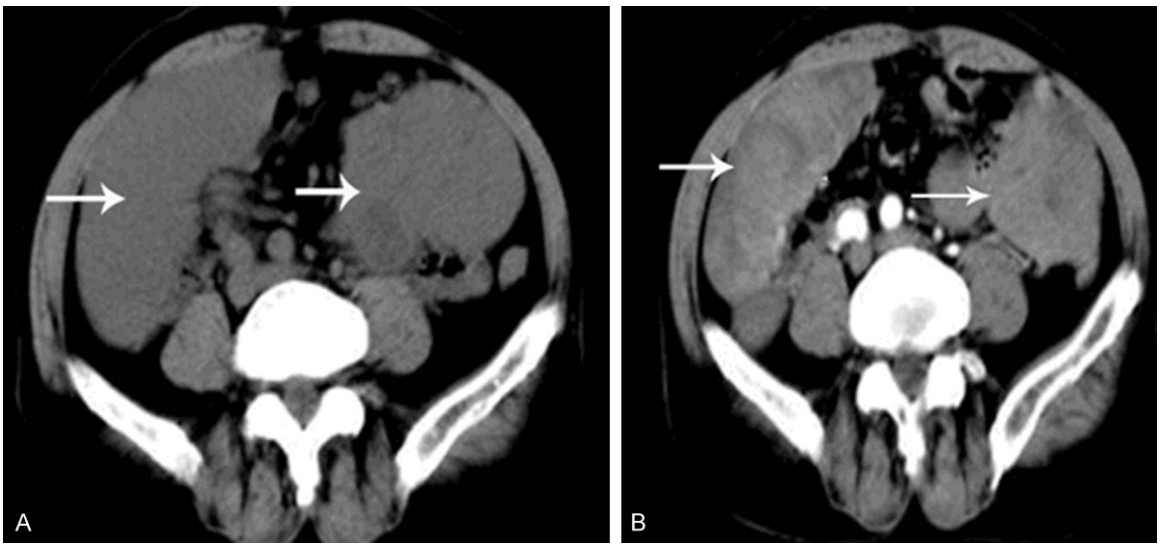

Figure 1. Multicenter IMT. A. Non-enhanced CT images showed two lesions of homogeneously intensity (white arrows). B. Contrast-enhanced CT images showed the absence of enhancing components (White arrows).

from all patients at our department from January 2006 to August 2011. This study was approved by our institutional ethics committee. Radiology databases were searched to identify patients who had confirmed IMT histopathologically and had undergone abdominal CT scanning. All the samples enrolled in this study were kept anonymously after retrieval of follow-up information. Previous comprehensive medical records of every patient were evaluated especially the history of abdomen inflammation or trauma. All medical details were supplemented by the out-patient and past hospital records. Demography, clinical and radiological presentation, pathological outcome were documented. All patients had full physical examination, including episodes of abdominal pain and antibiotics use. All cases had undergone abdominal unenhanced and contrast-enhanced CT scanning which was performed using a SOMATOM Definition double-source helical scanner CT (Siemens, Medical Systems, Germany). Associated imaging findings were also evaluated, including location, lesion number, diameter, contour and border of the lesion, the growth pattern characteristics, attenuation before and after contrast enhancement patterns. Standard parameters for spiral CT were 120 kVp, 120 mA s, the effective slice thickness was 5 mm. Arterial, venous and delayed-phase CT was performed after initiation of intravenous contrast medium injection of 80 ml

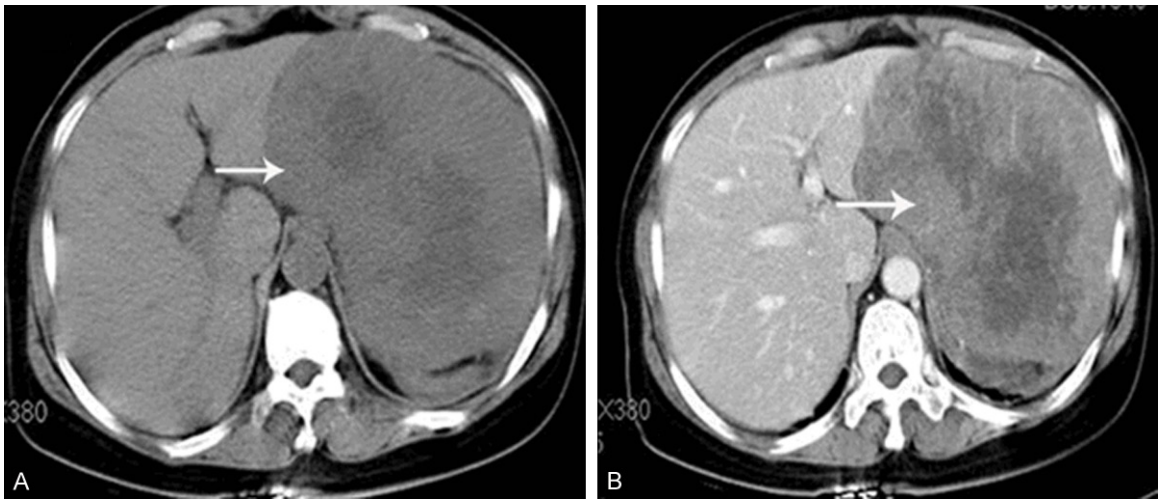

Figure 2. An unenhanced abdominal CT scan shows (A) a well-defined 13.5×15×14 cm large mass with scattered low-density areas in the center which suggestive of necrosis. (B) Contrast-enhanced CT images noted that the lesion was in heterogeneous enhancement patterns. There is a clear plane between the mass and the adjacent liver.

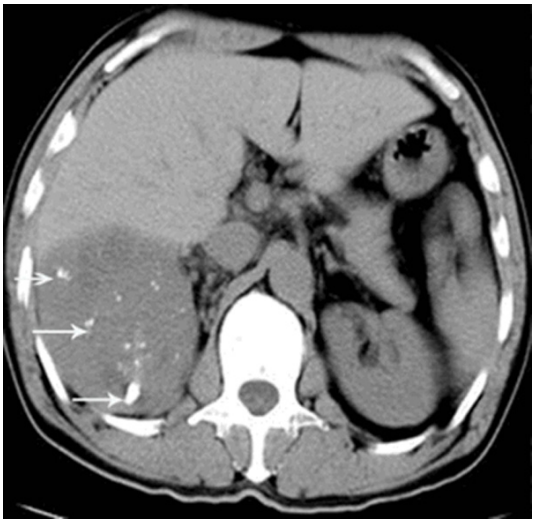

Figure 3. Abdominal CT scan showing the mass was well-defined and with multiply dotted calcification in the center (white arrows).

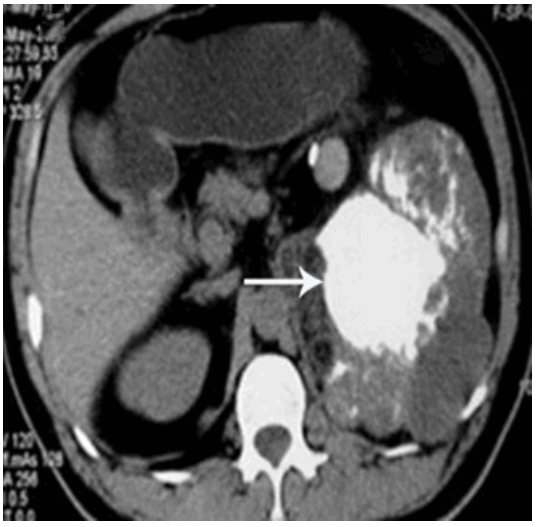

Figure 4. Non-enhanced abdominal CT image showing massive calcification changes extending into the mass (white arrow).

intravenous contrast material with a flow of 4 ml/s. The degree and pattern of enhancement of tumor spreading patterns were evaluated by two radiologists. All cases underwent laparotomy or performed imaging-guided biopsy and the final diagnosis of IMT was made after evaluation of specimen by two pathologists. All the histological material was evaluated according to the current WHO pathological criteria. Continuous variables with a normal distribution were expressed as mean ± standard deviation (Std). A *P*-value less than 0.05 was considered statistically significant. all statistical tests were carried out utilizing SPSS, version 17.

Results

Clinical data

Ten patients were enrolled in the investigation, the male to female ratio was 3:2, with a mean age of 25.4 years (range, 12 to 54 years). Patients presented with alimentary tract obstructive symptoms (n=5), abdominal pain (n=2), fever (n=2), and found incidentally (n=1).

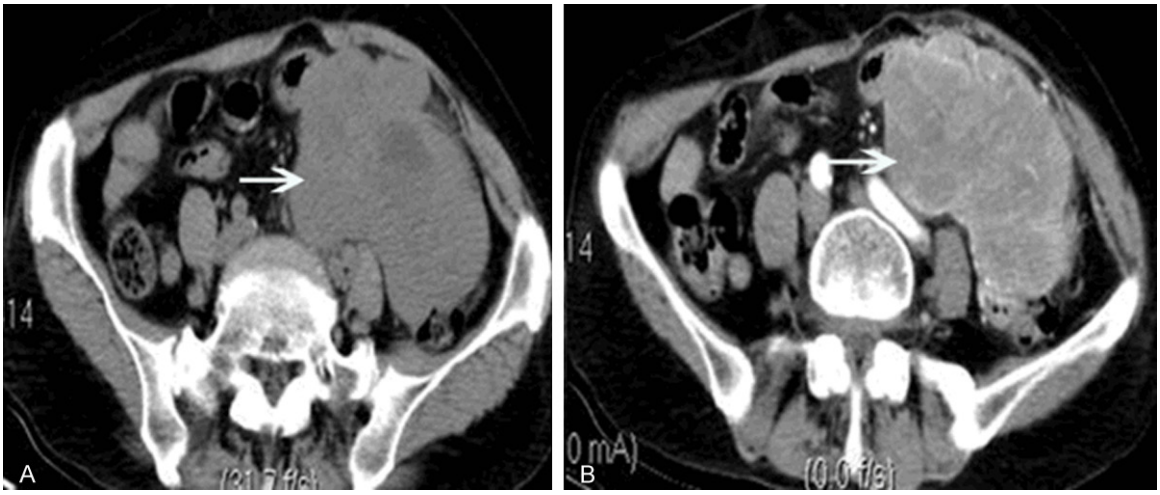

Figure 5. A. Unenhanced abdominal CT shows a 9×7×12.5 cm tumor with ill-defined and lobular appearance, thus simulating invasive malignant lesions. B. A contrast enhanced abdominal CT scan shows ill-defined heterogeneously enhanced infiltrative lesion in left abdomen.

The symptoms and manifestations are obviously depended on the location and the involvement organ. The most frequent physical finding was palpable intra-abdominal mass (n=6). The routine laboratory findings were nonspecific except for anemia (normochromic or hypochromic) in 4 cases leukocytosis in 3 cases, hyperglobulinemia in one case, elevated erythrocyte sedimentation rate (ESR) in 8 cases, and elevated C-reactive protein in 3 cases. Tumor markers such as Alpha Fetal Protein (AFP), carcinoembryonic antigen (CEA), CA 125, CA 19-9 were within normal limits (**Table 1**).

CT imaging findings

All cases underwent the abdomen CT scan, most tumors were intra-abdominal and only two masses were mainly located in the retroperitoneal space. Abdominal CT showed the tumors measuring 3.5 to 12.5 cm (median, 7.5 cm) were located in mesenteric and omental area (n =4), the colon area (n=2), and gastrointestinal region and displacement of bowel segments without demonstrable invasion and extended to the surrounding tissues (n=4). Among them, nine were solitary and only one case was multicentric (**Figure 1**). Six cases were well-defined, isodense masses, scattered low-density areas were found in four cases. Among them, one was multiple hypodensity lesions which suggestive of necrosis in the large mass (**Figure 2**) and multiple or dot-like calcification in two cases (**Figures 3**, **4**). No ascites and enlarged lymph nodes were noted. The edges of some tumors were ill-defined or with a lobular appearance (n=4), among them one case showed infiltrative appearance, thus simulating invasive malignant lesions (**Figure 5**). CT images frequently showed solid, well-circumscribed soft tissue masses with complete capsule which were indistinguishable from other solid tumors (n=6), the tumor density was similar to the soft tissue (about 30-45 HU) (**Figure 6A**). On unenhanced CT scan, slightly patchy low attenuation was seen in two cases.

On contrast-enhanced CT images, this enhancement is variable. In our study, we found moderately homogeneous enhancement in six cases (**Figure 6B**), and obviously heterogeneous enhancement in four cases (**Figures 1B**, **2B**, **5B**, **7B**) particularly on the venous and delayed-phase images. First, enhancement is broad and ill-defined at the periphery of the mass, and some lesion showed low attenuation in the centre while with a peripheral enhancing rim (**Figure 7**). The heterogeneous enhancement patterns is thought to depend on multiple factors such as abundance of inflammation, the related densely packed cells components (**Figure 8**). Most well-defined mass with slightly heterogeneous enhancement on CT images is usually observed. The infiltrative peritumoral margin may reflect the inflammatory characteristics of this tumor. In correlation with the histopathologic findings, lower attenuation found in contrast-enhanced CT corresponds to abun-

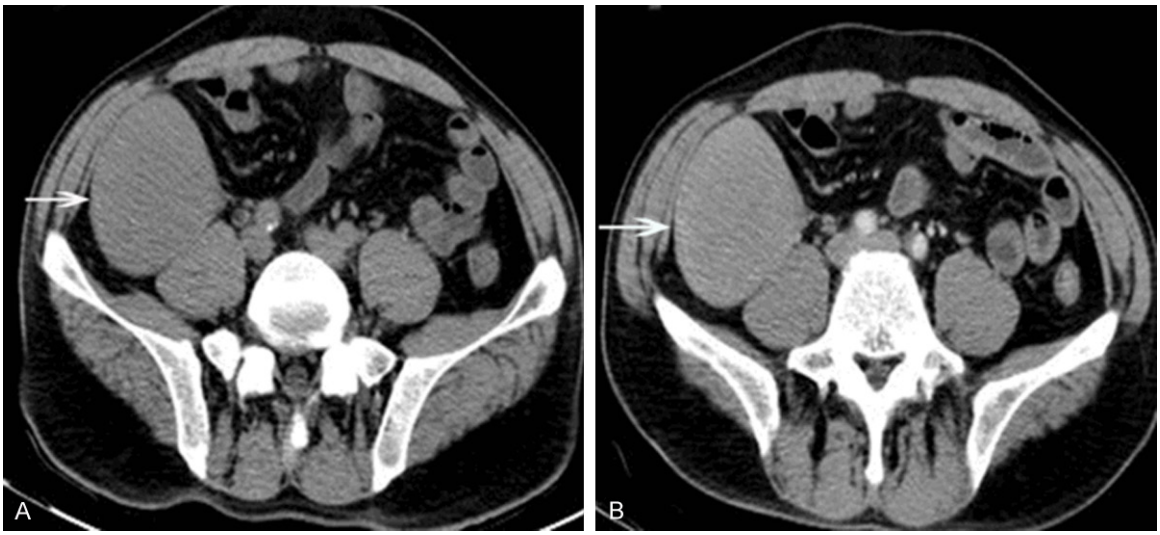

Figure 6. A. Non-enhanced CT scan showed a solid, well-circumscribed soft tissue mass with complete capsule. B. A contrast enhanced abdominal CT scan revealed moderately homogeneous enhancement.

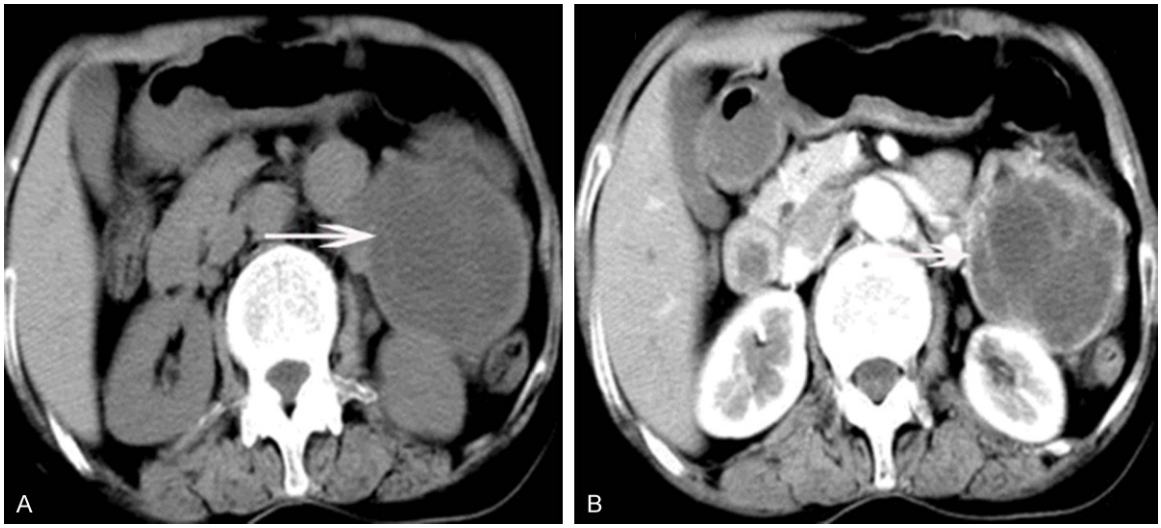

Figure 7. A. Non-enhanced abdominal CT imaging showed a well-defined hypoattenuating mass adjacent to the left kidney. B. On contrast enhancement CT, the lesion was with a peripheral enhancing rim while poorly enhancing in the center.

dance of fibrous tissue (**Figure 9**), while the hyperattenuating area is corresponding to the predominantly inflammation cells infiltration and hypervascularity density pattern or microvascular hyperplasia (**Figure 10**). These images and pathological results corresponded to the findings in this present study.

Pathology and immunohistochemistry

Grossly, six specimens had complete capsule and indistinct capsule was found in four cases. The cut surface showed a fleshy texture with regions of grey-red appearance. Patchy necrosis areas and haemorrhage were noted in two cases, obvious calcification was found only in one case. The specimen section demonstrated the tumor cells were mainly arranged in fusiform pattern and the characteristic features were the presence of spindle cells with an infiltration of lymphocytes and eosinophils, occasional atypical cells with mitotic nuclei Figure ureures can be seen. The spindle cells showed bland, vesicular, round to oval shaped nuclei and possessed abundant eosinophiliccytoplasms imparting myofibroblasts. The mesen-

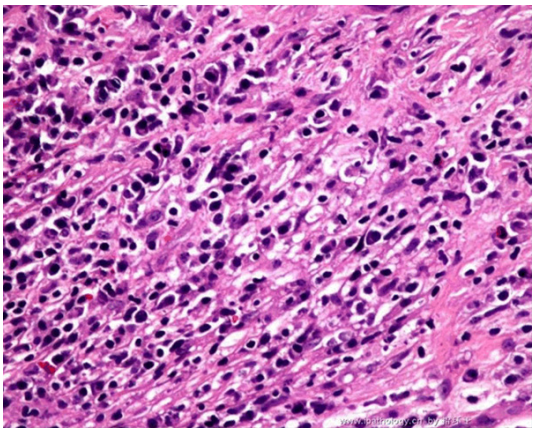

Figure 8. Microphotographs of hematoxylin & eosin-stained sections showing abundance of spindle cells arranged in storiform pattern, admixed with inflammatory cells (×200).

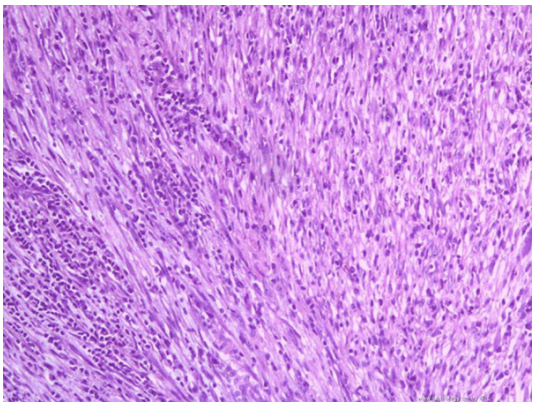

Figure 9. Microphotographs of hematoxylin & eosin-stained sections showing sparsely cellular areas with abundant fibrous stroma and scattered inflammatory cells (×100).

chymal component, generally regarded as having morphological features consistent with mucoid degeneration. Immunohistochemically, the lesions expressed smooth muscle act in (8/10, 80%), desmin (9/10, 90%), vimentin (9/10, 90%) (**Figure 11A**), and anaplastic lymphoma kinase-1 (7/10, 70%) (**Figure 11B**), negative for CD 117, CD 34 and S 100. On the basis of histology and immunohistochemistry, the pathologic diagnosis was inflammatory myofibroblastic tumor. In our cases, IMTs can be classified into two different subtype entities based on major morphologies findings. The lesions may range from fibrosing inflammatory lesions to a myofibroblastic appearance with heavy infiltration of inflammatory cells, accompanied with various vessels. The most common type was abundant in compact spindle cells with inflammatory and vascular areas. (**Figures 8**, **10**) The other subtype was a desmoid-like pattern with myxoidfibrer and hypocellular area (**Figure 9**). There was no evidence of purulent material or acute inflammatory cells such as neutrophils within the lesion. The pathological assessment and further subclassifications of the lesion was listed as follow (**Table 2**).

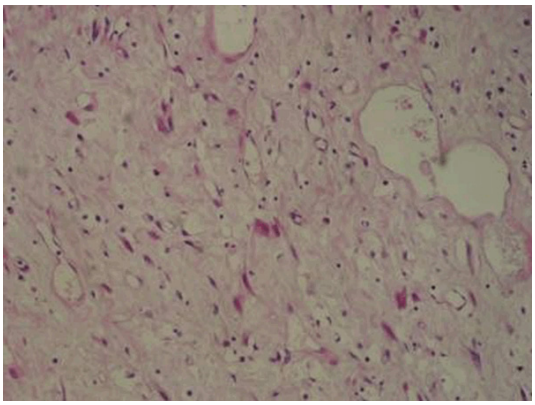

Figure 10. High-power view showing those spindle cells with abundant inflammation cells infiltration and the hyper vascularity density pattern was consisted of microvascular hyperplasia (×400).

Discussion

Originally, IMT is proposed as a post inflammatory reactive process, occurring after surgery or trauma. Several terms have been used to describe this entity including “inflammatory pseudotumor”, “inflammatory myofibrohistiocytic proliferation”, “inflammatory fibrosarcoma” and atypical myofibroblastic tumor. To avoid ambiguity, these designations are best avoided according to WHO which IMT is classified as an intermediate biological potential tumor with distinct clinicopathological entities and different from inflammatory pseudotumor [3]. Previous studies have attributed etiology to an immunological response to viral -8 or bacterium infection [4, 5]. But there is no evidence of a proven relationship between IMT and any specific infectious agent in our investigation.

Demographic data and clinical history have little help in the diagnosis. Children and adolescents constitute the majority of IMT, there is no sex predominance. IMT can occur in any anatomical location and predominantly arise in the

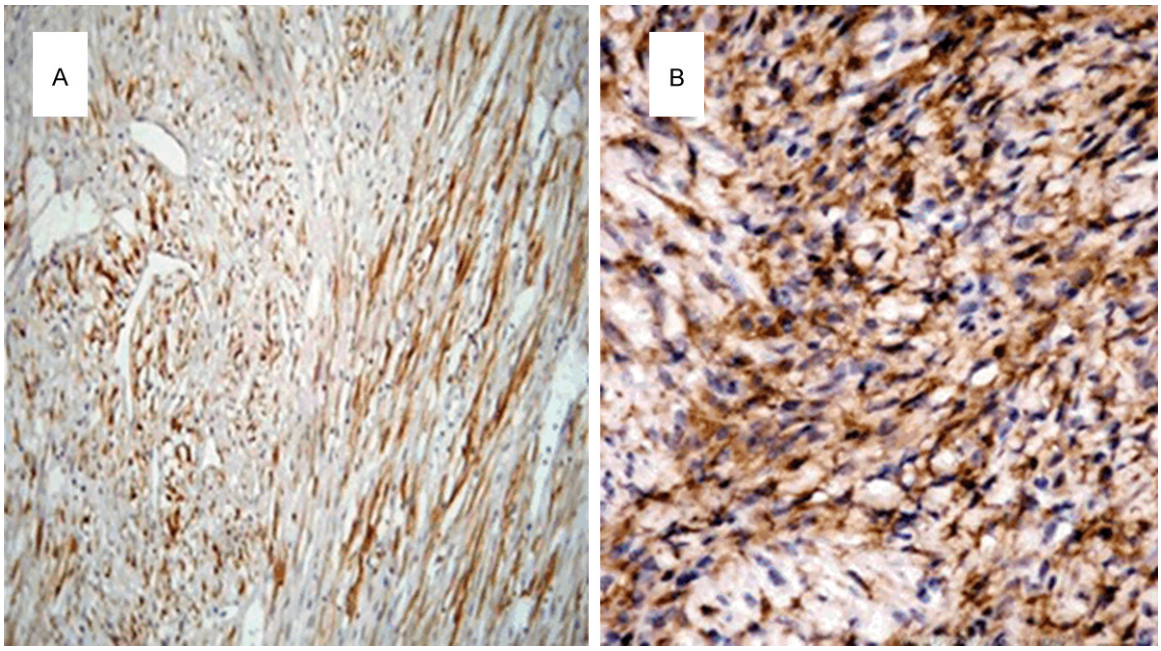

Figure 11. Microphotographs of immunohistochemical stains showing: A. Diffuse cytoplasmic immunopositivity for SMA in tumor cells. (×100); B. ALK is expressed in tumor cells (×200).

lung, occasionally in head and neck, extremities, urinary tract, pelvis, retroperitoneal region [6-8]. The abdomen is the most extrapulmonary region and the lesion can be solitary or multicentric. Those occurring in the mesentery, omentum, retroperitoneum and pelvis tend to be of large dimensions. The symptoms and manifestations varied according to the location and dimension of the lesions, abdominal distention is the most common symptoms. According to the literature, 19% were accompanied by systemic symptom, such as fever, gastrointestinal symptom, and weight loss or can be found occasionally. The lesions revealed different growth patterns, leading to obstruction or displacement of bowel segments. Rapid growth and multicentre appearance of these masses simulated malignancy. Some abdominal IMTs were associated with inflammatory signs and symptoms related to their local spread. A palpable mass may be the clinical presentation in abdomen that often mistaken for malignant neoplasms, such as sarcomas, lymphomas or gastrointestinal stromal tumor (GIST). Demographic data and clinical history have little help in diagnosis. Raised serum levels of IL-6 reported to be found in IMT patients and returned to normal postoperatively [9]. The elevated IL-6 and ALK gene rearrangements may have a potential role in diagnosis. Positive ALK status is more frequent in aggressive tumors, whereas ALK-negative IMTs were associated with metastases [10]. But in our study, there was no examination of IL-6, and ALK was positive in about 80% in all cases.

Although CT may offer suggestive features, while the entity in the abdomen is exceedingly rare and difficult to obtain a definitive diagnosis. The radiologic features of intra-abdominal IMTs are non-specific, radiological investigations are often inconclusive owing to absence of pathognomonic features. Occasionally, some had an infiltrative appearance and ill-defined margin features and indistinguishable from malignant lesions [11]. If a spontaneous or slight regression is noted, then IMT should be considered. Confirmed diagnose is usually obtained only by biopsy or surgical intervention. Radiologically, IMT is rarely suspected before operation due to the low incidence of this tumor. Nevertheless, imaging plays its role on pre-operative planning by delineating the extent of the disease and decision of surgical scheme [12]. Considerable similarities between IMT and malignant tumor make the differentiation difficult before operation. All our cases were misdiagnosed as malignant or gastrointestinal stromal tumor on preoperative CT evaluation.

Table 2. Radiologic and pathological features of abdominal IMT

NO.	Unenhanced CT Findings	Enhanced CT Findings	Histological findings
1	Lobulated, isodense, solid mass	Obviously inhomogeneous enhancement	Abundance of inflammatory cells, dense hypervascularity
2	Well-circumscribed, central low density	Slight enhancement	Myofibroblasts and fibrous tissue lack of inflammatory cells
3	Ill-defined, low-isodense incomplete capsule	Obviously inhomogeneous enhancement	Mucoid degeneration, thickened microvessel
4	Well-defined, low-isodense complete capsule	Obvious enhancement in peripheral enhancing rim	Central mucoid degeneration, inflammatory cells infiltration rim
5	Multiloculated, isodense well-defined, solid lesions	Moderately heterogeneous enhancement	Packed myofibroblasts and abundant inflammatory cells
6	Well-defined, isodense, solid, complete capsule	Oderately homogeneous enhancement	Abundant myofibroblasts and inflammatory cells
7	Ill-defined, obviously calcification	Slightly inhomogeneous enhancement	Abundant myofibroblasts, fibrosis calcification and hypovascularity
9	Well-defined, low-isodense	Obviouly inhomogeneous enhancemen enhancement	Abundant inflammatory cells hypervascularity
10	Well-defined, sporadic calcification, solid complete capsule	Obviouly homogeneous enhancemen enhancement	Abundant myofibroblasts, inflammatory cell, hypervascularity

The literature on radiological appearance is less, and there are many conflicting opinions regarding the CT imaging. In previous study, owing to the mixed histologic character, imaging characteristics of this tumor's subtypes by correlation with the pathology was not possible [13]. While in our series, most lesions were homogeneous on unenhanced CT imaging and contrast-enhanced CT imaging is variable. With reference to the limited radiological description, IMT appeared as heterogeneous solid mass with well-circumscribed margin, calcification and central necrosis [14]. In previous study, CT demonstration of prominent enhancement was suggestive of regional inflammatory changes, supporting the diagnosis of IMT [15]. When correlating the CT features with the histological findings, the heterogeneous enhancement in agreement with the components of the cellular and fibrous tissue especially the vascular density. The hypo-enhanced areas correlated with the fibrous or desmoid-like tissue, while the hyper-enhanced areas corresponded predominantly with the inflammatory cells and proliferative micromodule. In addition, a blur margin of this unencapsulated tumor may reflect an inflammatory characteristic.

Recognition of this rare entity is important because the clinical manifestations and radiological features may be indistinguishable from a malignant disorder. Histopathologically, calcification, hemorrhage, necrosis, and aggressive features can be found in a minority of cases. The tumor cells were mainly arranged in fusiform pattern with an inflammatory infiltrate and occasionally mitotic Figure ureures and atypical cells with large nuclei can be seen. IMT has a wide variation in histological appearance including three major subtypes: fibromyxoid and vascular pattern, proliferating pattern, and sclerosing pattern [10]. While in our radiological and correspondingly histological study, there are two major subtypes were available for classification. Immunohistochemically, the tumor was positive for smooth muscle actin, desmin, vimentin, and anaplastic lymphoma kinase-1 (ALK-1), negative for CD 117, CD 34 and S100. Molecularly, approximately 50% of IMTs show ALK gene rearrangement. Rare IMTs with a nuclear membrane or perinuclear pattern of ALK staining, suggesting that such patterns may predict malignant behavior [16]. IMT should be differentiated from diagnosis of a malignant tumor because of its local invasiveness and tendency to recur. The aggressive course and the malignancy were related to different biologic and morphologic tumor features remains controversial. Pathologic features did not appear to be related to an unfavorable clinical course, do not correlate well with clinical behavior.

Although most IMT is benign, its behavior may be unpredictable. Multifocal and atypical lesions are prone to recurrences or metastasis. The lesions can be ill-defined and with extensive adhesion to adjacent structures that need radical excision. Complete surgical resection appears to be the most appropriate management in current option. Computed tomography examination can help to determine the areas involved by lesions which facilitate the prediction of the likely surgical requirements. However, spontaneous regression or after nonspecific medical treatment such as anti-inflammatory or antibiotics drug has been reported [17, 18]. Anti-inflammatory drugs may eradicate large IMTs or shrink them to a resectable size [19]. When surgical management is not possible, chemotherapy and radiotherapy have been attempted. Chemotherapy may be considered for in the treatment of advanced and unresectable IMT [2, 20]. Nevertheless, there is no consensus on adjuvant therapy agent and no randomized controlled trial evidence is available to support routine use of chemotherapy or radiotherapy in complete resection currently. Metastasectomy may be enough to treat relapse and metastatic lesions [21, 22]. Additionally, ALK tyrosine kinase inhibitors represent a potential promising modality for targeted adjuvant therapy for incompletely resected and unresectable tumors [23].

There is no proven role with variable success and reliable prognosis reappraises the biologic behavior of IMT. According to the literature, abdominal and pelvic IMTs lesions had a recurrence rate of 22%~85%, a tendency for distant metastasis in <5%, The cure rate following excision is about 67%, 1.8% of the patients have died due to metastatic disease [24]. The 5-year and 10-year survival rates were 87.4% and 72.8%, the cure rate following complete excision is about 67% [25]. In all, the optimal medical management are controversial and should be decided individually and require further studies.

Conclusions

No pathognomonic radiology character was noted in abdominal IMT cases, it cannot be differentiated from a malignant tumor and other soft-tissue tumors based on radiographic appearance alone. CT imaging findings especially enhancement may reflect the histological composition of the tumors. Variable CT features among the tumor concerning the degree of enhancement should suggest the possibility of coexisting subtypes of IMT. Awareness of these different radiological findings and histopathological features may help improve the diagnosis and prevent unnecessarily aggressive therapy.

Disclosure of conflict of interest

None.

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