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Imaging study to establish the classification criteria of brucellar spondylitis based on MRI findings

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Abstract

Objective: *Establishment of brucellosis spondylitis of imaging classification; provision reference for clinical treatment methods.*

Methods: *Form January 2008 to July 2012, 89 cases imaging data confirmed by clinical examination and laboratory of brucellosis spondylitis patients were analyzed retrospectively, based on X-ray, CT and MRI imaging of their clinical manifestations- Vertebral inflammatory infiltration and extent of the damage, the extent of damage to the intervertebral space, periostitis inflammatory changes, paraspinal abscess, spinal cord, cauda equina and nerve root compression. All this imaging indicators above were the evaluation criteria. Acquisition and analysis of the imaging data was implemented by the blinded reading group which was composed of Imaging Center physicians and orthopedic surgeons. According to these imaging performances, develop the imaging classification.*

Results: *Brucellosis spondylitis image was made up of I-VI type: type I: vertebral inflammation; type II: Discitis; type III: periostitis; type IV: abscess; type V: spinal nerve and type VI: compound. The group of 54 cases accounted for 60.67% of the compound, in which the incidence of type I Image companied by type II was maximum: 22 cases accounted for 40.74% (22/54) and second type II Image and companied by V type was 20 cases: accounted for 37.03% (20/54). In the group, 35 cases of simple type accounted for 39.33%: type I: 4 cases; type II: 12 cases; type III: 3 cases; type IV: 2 cases; type: 4 cases. Simple and complex type of type II imaging accounted for 59.55% (53/89) the highest occurrence rate, in which the type I was 47 cases: accounted for 52.81% (47/89). Based on imaging classification, 67 cases was treated by surgery, in which 59 cases was treated by debridement and 8 cases was treated by percutaneous minimally invasive surgery, 22 cases was not treated by surgery. The group of 89 cases had been followed for 1 year: 83 cases had been cured without prognosis, and 6 cases had been improved.*

Conclusion: *Brucellosis spondylitis images classification has a reference value and guiding significance for the strategies of clinical treatment. According to this classification, simply type I, type II, type III, and IV type can be used in clinical conservative treatment, and when the evolution of the disease has surgical indications, or type V and VI type the patients should be treated actively by surgery.*

Keywords: Brucelliasis, Spondylitis, X-ray, Computed Tomography, Magnetic Resonance Imaging, Imaging Classification, Clinical Treatment

Introduction

Brucellosis spondylitis (BS), caused by the invasion of the contagious zoonotic Brucella, is infectious spondylitis which influences the mobility of the spine and the function of the spinal nerves and cauda equina badly [1]. The disease often leads to restrictions on the mobility of the spine and leads to compression of cauda equina and spinal cord. Due to the lack of specific clinical manifestations, imaging findings has a character that Brucellosis spondylitis confused with other diseases easily, especially the spinal tuberculosis, so it leads to misdiagnosis and wrong treatment with ease [2]. In recent years, BS incidence has increased yearly. With the deep insight into research for brucellosis spondylitis, the imaging performance of BS is understood correctly, and according to its type of clinical imaging findings, standardized treatment to guide the disease has important significance. A total of 268 patients diagnosed with BS from January 2008 to December 2022 were selected. Imaging data of their imaging findings were analyzed to establish magnetic resonance imaging (MRI) typing criteria, which could provide reference for clinical diagnosis, differential diagnosis and treatment strategy formulation. The report is as follows.

Methods and Design

Discussion of Imaging Findings and MRI Classification of BS

Date and Study Site

Research done in the First Affiliated Hospital of Hebei North University, Zhangjiakou City, Hebei Province, China from 2008-01 to 2022-12.

Clinical Data

The group of 268 cases has 162 males and 106 females, aged 24 to 65 years, and its average age is about 46. All patients had a history of exposure to varying degrees of BS, including contact with sheep and cattle, drinking unpasteurized and infectious dairy products, eating beef and mutton. A part of the patients live in endemic areas. The period of disease is from 6 months to 29 months, and average period is about 10 months. Diseased parts were distributed in the lumbar (138 cases), lumbosacral vertebrae (62 cases), thoracolumbar spine (41 cases), thoracic vertebra (27 cases). The highest incidence occurred in lumbar accounted for 51.49% (138/268 cases). The group of 268 cases got slow onset, and all the patients were associated with relaxation- type fever (body temperature does not exceed 38.5), fatigue, night sweats, pain of chest and back, and persistent lower back pain, and also associated with radioactive limb pain or numbness, local tenderness, percussion pain, muscle spasms, and the extreme limit of spinal movement. Patients were afraid to walk or stand up because of the severe pain and often in a fixed position. But there were no kyphosis. 67 cases had abscess formation and 128 cases were correspondingly associated with compression symptoms of spinal cord, cauda equine, and nerve root.

Imaging Inspection

The group of 268 cases had a X-ray, x-ray computed tomography (CT) and MRI examination. Imaging showed 211 cases of 2 vertebrae invasion and 9 cases of 3 vertebrae invasion.

The X-ray showed that 183 patients had narrow spine gap and spine density increased in which 61 cases' vertebral articular surface were destroyed. Also showed 234 cases' vertebral edge were destroyed, with irregular worm-eaten shape, and around the lesions, the vertebral edge had gotten sclerosis and hyperplasia in which 46 cases showed beak-like unstructured dense shadow extending outward or to the direction of adjacent vertebra and forming bone bridge. In which 38 cases' facet were destroyed with spinal instability or mild spondylolisthesis. In which 42 cases' bone destruction lesions were bigger, more than 1.5 cm, of which 29 cases showed island shape located on the edge of the vertebra, and 13 cases showed hole shape located in the center of the vertebra and in which 72 patients widened soft tissue around the vertebra or psoas shadow.

The CT showed: 176 cases showed that intervertebral disk was damaged with the shadow of even density, the edge of articular surface had had the hyperplasia and the sclerosis, and there was destruction in the central of the bone. 205 cases showed that the bone lesions were hairlike, round and hypodense, and were mostly less than 5 mm diameter. The trabecular bone was thick and disorganized. The edge of the lesions had obvious and varying degrees area of hyperplasia and the sclerosis, distributed on the edge vertebra. The new lesions were seen in the new bone. 38 cases showed that facet joints were also seen the similar change above. Among these cases, 38 cases were seen larger lesions in the center of the vertebral, presenting hole like shape.116 cases showed vertebral periostea were hypertrophy, bulging from the middle to the sides, so the vertebral had unequally increased density with mottle deformed with a shape of shuttle. The periosteal of vertebral edge had hypertrophy and calcification, forming a "lip" osteophytes, and the newborn osteophytes plused lesions constituted the "lace vertebral" characteristic features, but the calcification between the vertebral and periosteum had still been legible, linking adjacent vertebral osteophytes so that formed the fusion of vertebral lateral and the calcification of anterior longitudinal ligament. The transverse protuberance of periosteum of 42 cases showed the transverse top thickening just like a cap. 72 cases showed that the shadows of paraspinal soft tissue were connected with the vertebral lesions with irregular shape, clear boundaries, pushing the adjacent psoas.

MRI showed: the vertebral spaces of 176 cases were narrow, intervertebral disc had inflammatory changes, T1WI showed low signal, and T2WI were mixed as high signal. Adjacent vertebral endplate bone was destroyed, in which schmorl snode destruction is characteristic expression. The vertebral edge of 205 cases had the moth- eaten bone destruction and inside the vertebral body, there was diffuse marrow edema. T1WI showed homogeneous or uneven low signal, T2WI showed mixed long T2 signal, and STIR showed uneven high signal with uneven enhancement after enhancement. Around the vertebral lesions, there was visible vertebral bone sclerosis, presenting short flaky T2 signal. 46 cases showed vertebral bone obvious hyperplasia, presenting the shape of beak-like so that formed the bone bridge. 38 cases were associated with facet joint destruction with T1WI showing low signal, T2WI showing high signal, and STIR showing uneven high signal. 38 cases showed spondylolisthesis with spinal instability. 48 cases showed the front or the back of vertebra had been seen the ossification shadow of the anterior longitudinal ligament or the posterior longitudinal ligament. 42 cases had been seen the transverse protuberance periosteal ossification shadow, in which T1WI showed strip equal signal and T2WI showed strip low signal. Next to the vertebra, 72 cases had been seen unclear boundary abnormal signal of soft tissue.T1WI showed low signal, T2WI showed mixed signals. Through the enhancement scanning, soft tissue near the vertebra showed the flaky enhancement, which had been seen as a thin, irregular enhanced abscess wall. 123 cases showed in the spinal canal, epidural abscess and destruction of intervertebral disc could be found, and meanwhile, inflammatory granulation breaking into the spinal canal or the calcification of posterior longitudinal ligament could be found, too. In the corresponding plane, spinal cord, cauda equina, or nerve root had been compressed. T1WI showed homogeneous or uneven low signal, T2WI showed high signal, and STIR showed uneven high signal.

Imaging Analysis

Two Imaging Center physicians and three orthopedic surgeons constitute film-reading group. They severally collected and analyzed the data at different times from the following phenomenon: diseased parts, vertebral body, intervertebral inflammatory infiltration, the extent of damage, facet joints, changes of paraspinal soft tissue, and compression of spinal cord, cauda equina, and

nerve root, and so on. Then the doctors recorded the data to make Imaging analysis. Finally, five physicians observed the patient's characteristics together and then made comparisons.

Results

All patients in this group were diagnosed by the First Affiliated Hospital of Hebei North University, Zhangjiakou City, Hebei Province China and Local Center for Disease Control, Zhangjiakou City. All of this conformed to the the Diagnostic criteria for brucellosis spondylitis [2]. The lesions in this group were distributed on the two vertebras at best, and the following lumbar had highest incidence: L4-5 40.298% (108/268 cases), L5S1 23.13% (62/268 cases), L3-4 11.19% (30/268 cases). Involving vertebral lesions was L5 at best.

BS imaging findings of 268 cases showed as follows: Simple inflammatory infiltration and vertebral bone destruction (type I vertebral inflammation) were 14 cases. Simple intervertebral disc damage (type II discitis) was 12 cases. Simple vertebral periostitis (type III periostitis) was 3 cases. Simple paraspinal abscesses of soft tissue or psoas abscess (type IV abscesses) were 2 cases. Simple spinal cord, cauda equina or nerve root compression (type V spinal nerve) were 4 cases. Processing two or more types above (type VI compound) were 54 cases, in which type I companied by type II were 8 cases, type I companied by type IV were 5 cases, type I companied by type V were 6 cases; type II companied by type III were 3 cases, type II companied by type IV were 7 cases, type II companied by type V were 9 cases; type V companied by type IV were 3 cases; type I companied by typeII and type IV were 8 cases; type IIcompanied by type II and typeVwere 3 cases, typeIcompanied by type II, type IV and type V were 8 cases.

Therefore, in this group, 54 cases were compound type accounted for 60.67%,and 35 cases were simple type accounted for 39.33%, in which type I were 14 cases, type II were 12 cases, type III were 3 cases, IV type were 2 cases, and V type 4 were cases. In simple and complex type, type II imaging was the highest occurrence rate accounted for 59.55% (53/89) , in which the type I were 47 cases, accounted for 52.81% (47/89); type II companied by typeIwas the highest rate of radiographic appearance, accounted for 40.74% (22/54); Secondly type II companied by typeVwere 20 cases, accounted for 37.03% (20/54), type I companied by type V were 17 cases, accounted for 31.48% (17/54).

In the group, all the 89 patients underwent standardized pharmic treatment. Based on the above imaging performance, the total 67 patients, who had intervertebral serious infection, intervertebral disc damage, destruction of the bigger vertebral lesions, paraspinal abscess or psoas abscess, vertebral instability, and spinal cord, cauda equina, or nerve root compression, used the surgical method of treatment, in which 59 were treated with debridement surgery, 3 cases were treated with aspiration of minimally invasive percutaneous abscess, and 5 cases underwent the cutting disc lesions of minimally invasive percutaneous absorption and the pathological examinations of 67 cases were all in line with Brucella bacteria histological disease, and the remaining 22 patients were conservatively treated simple drug treatment. The group of 89 cases had been followed up for 1 year, according to BS clinical evaluation criteria [1-4]: 83 cases were cured, and 6 cases were improved. All the patients had no relapse.

Discussion

Brucellosis can invade any part of the body's bones and joints, especially in the spinal lesion, causing characteristic infection of the spine discitis (type II) or characteristic vertebral inflammation (I type), with the highest incidence of L4-5. In this group, the highest incidence was lumbar accounted for 50.56%, and in the lambar, two vertebral bodies involved at best, in which L4-5 was 40.44%. In accordance with BS imaging, their performance would be detailed and classified; characteristic of each type of imaging performance would be summarized, providing reference for clinical diagnosis and treatment.

Imaging Findings and Clinical Classification of Brucellosis Spondylitis

Type I: Vertebral Inflammation

X-ray findings: Spinal lesions often coexisted with other disease of bone and joint, mainly affecting the lumbar spine which could involve 2-3 vertebrae. The destruction at the edge of vertebral bone was the most common type with multifocal lesions mostly encroaching on the upper edge of the 1-2 vertebral body. The damage of three vertebrae bones was less. The spinal lesions early presented little osteoporosis, and after a few weeks, appeared the bone defect lesions in which the bigger lesions looked like islands. Lesions presented soft tissue's density without sequestrum, but with sharp and clear edges. The spinal lesions also presented irregular worm-eaten destruction or knife saw- like appearance, often companied by irregular surface damage of facet joint and progressive narrowing of joint space resulting in the disappearance of joint space and unstable spine.

Latterly, there was low degree vertebral spondylolisthesis, and bone's sclerosis and hyperplasia formed the bone spurs, like beak extending outside or to the edge of adjacent vertebral, thus they formed bone bridge. The facet joint, however, produced the hypertrophic secondary arthritis, resulting in ankylosis, and a number of joints involved. Vertebral center may have been violated, and the center of the vertebral body lesions usually hardened rapidly, forming deep bone destruction and defect, but no signs of vertebral compression [5].

CT findings: the bone lesions was mostly less than 5 mm in diameter, multiple, round, and hypodense. Vertebral center and edge can be violated [6]. Trabecular bone was thick and disorganized with unclear structure. The edge of lesion was sharp, clear, and irregular. In which larger lesions looked like islands, surrounded by unclear osteoporosis, but they obviously had varying degree of sclerosis, located at the edge of the vertebral body. In the newborn bone, vertebral density had generally increased near the adjacent vertebral lesions without sequestrum and destruction of vertebral heel, but there were signs of damage to facet joints. Yang et al. [7,8] think that the patients were not seen the vertebral expansion,

cracked damage, or a large area of defect in CT. The main damage occurred in the front of, the middle of spinal column, and in the facet joint, both of which affected the stability of the spine, but it did not involved the internal spinal canal, and paraspinal abscess was not seen.

MRI findings: In addition to CT, there was abnormal signal in the soft tissue of spine vertebral edge: T1WI showed low signal; T2WI high signal. Vertebrae presented diffuse marrow edema. T1WI showed homogeneous or uneven low signal; T2WI showed mixed long T2 signal. When the bone was obviously destroyed, T2WI showed high signal and STIR showed uneven high signal with uneven enhancement. The vertebral body lesions, inflammatory granulation tissue or bone abscess [9,10] could be found. This type was often accompanied by the destruction of facet joint. T1WI showed low signal; T2WI high signal; STIR showed uneven high signal, resulting in spinal instability with spondylolisthesis. Bozgeyik et al. [11] reported that during BS acute vertebral lesions, the weighted imaging had showed low signal in MRIT1; the weighted imaging had showed high signal in T2WI; for subacute and chronic vertebral involved, the weighted imaging had showed uneven signal in T1WI and T2WI with enhancement of signal compared to the acute T1WI signal.

Type II: Discitis Type

X-ray findings: Early characteristics of disctis were narrowing intervertebral space, increased density, irregular surface of the upper and lower vertebra, irregular edge of vertebra, and a tendency to bone destruction. Latterly, there was sclerosis and hyperplasia at the edge of the vertebral bone, and there was calcification near the ligament.

CT findings: The damage of vertebra was all companied by the adjacent vertebral narrowing intervertebral space, and the damage of intervertebral disc. CT showed a shadow of equal density. Because the destruction of intervertebral disc was often simultaneously accompanied by a lot of fibrous tissue, articular surface showed sign of sclerosis and hyperplasia [2].

MRI findings: Normal anatomy for the nucleus pulposus of intervertebral disc disappeared at different levels, and the central "fissure" sign disappeared. With Narrowing intervertebral disc and the inflammatory of intervertebral disc, T1WI showed low signal, while T2WI showed mixed high signal. Adjacent vertebral endplate bone was destroyed, often accompanied by bone marrow edema, fat deposition and fibrosis calcification, of which Schmorl snode bone destruction is characteristic performance [12,13].

Type III: Periostitis Type

X-ray findings: Early, there were periostitis reactions in the front of vertebra with osteoporosis. Latterly, periostea grew hypertrophy and calcification accompanied by calcification of anterior longitudinal ligament, forming a "lip" osteophytes, or forming a bone bridge together with adjacent vertebral edge. It showed the gradual development anterior and posterior longitudinal ligament from bottom to top, forming a strip shadow of calcification [7], and transverse periosteal calcification shadow.

CT findings: Vertebral periostea were hypertrophy, bulging from the middle to the sides, so that the vertebral body increased uneven and mottled density with deformation of the spindle. Periostea at the edge of vertebra were hypertrophy and calcification, forming a "lip" osteophytes that plus other lesions inside constituted the characteristic features of "lace vertebrae". But the gap between calcification of the periosteum and vertebral periosteum still could be legible and adjacent vertebral osteophytes were connected to form blend on the side of the vertebra. Sometimes the transverse process of periosteal presented transverse process of shape, and thickening just like a cap [2,7].

MRI findings: Early there was an abnormal signal of vertebral edge or transverse periosteal tissue edema- T1WI showed low signal, T2WI high signal. Latterly, at the edge or back of the vertebra, the anterior longitudinal ligament or the posterior longitudinal ligament presented the shadow of transverse periosteal ossification- T1WI was strip equal signal, T2WI showed low strip signal.

Type IV: Paraspinal Abscess or Psoas Abscess

X-ray findings: Early characteristic was that the spine was not been destroyed; the shadow of the soft tissue near the spine widened with the shape of spherical, cylindrical or spindle; or the shadow of the psoas on both sides spine was blurry, widened, full, and general asymmetric. Latterly, vertebral bone there were rough edges at the edge of spine, and a lot of scattered calcification shadows were seen in the soft tissue or psoas.

CT findings: The shadow of the soft tissue near the spine was connected to the vertebral lesions with irregular form and clear boundaries, pushing adjacent psoas muscle. BS reported the incidence of paraspinal abscess or psoas abscess was very low, only from 1/10000 to 2/10000, there is no obvious characteristic feature of partial tissue reaction [5,6]. The group had 26 cases of which psoas widened on both sides of the vertebral body destruction, within which there are abscess formations with clear space around the fat, but the abscess lingers had no direct signs [2].

MRI findings: In the center of the lesions, there was soft tissue lump. From the center to sides, the bar-like or fusiform shadow of abnormal signs could be found near the vertebra. And the shadow was located in the front, back or both sides of the vertebra. The weighted imaging of T1 was low or medium signs; the weighted imaging of T2 was low or high mixed signs; after enhancing scan, they presented bar- like enhancement. The abscess behind the vertebra compressed the dural sac, violating bilateral or unilateral psoas muscle. T1WI showed low signal; T2WI high signal, and the edge of them was unclear, after enhancing scan, the center of the lesions was sheet enhancement [12]. In this group of MRI, 26 cases were found the paraspinal abscess or psoas abscess.

Type V: Spinal Nerve

Based on I- IV type, the type V was associated with spinal cord, cauda equine, and nerve root compression symptoms. X-ray and CT only showed the imaging characteristics feature of I-IV type. Besides these characteristics above, MRI showed that there was

abnormal and unclear boundaries signal of soft tissue in the canalis spinalis. T1WI showed low signal, T2WI high signal, and STIR showed uneven high signal in the the canalis spinalis. It could be identified that there was spinal epidural abscess, intervertebral disc was damaged or inflammatory granulation tissue broke into the canalis spinalis so that the spinal cord, cauda equina, or nerve root was compressed [9,10,14]. In this group of MRI, 59 cases were found the performance above.

Type VI: Compound Type

In addition to these five types above, BS imaging showed there mostly were two or more types coexisting. But in these types of imaging, a certain type was chief of all, accompanied by partial performance of other types, so, it was referred to as "compound". in the group of imaging findings, 60 cases of 89 cases were compound type, accounting for 67.41%, and 29 cases were simple type accounted for 32.59%, in which type I were 15 cases, type II were 7 cases, type III were 3 cases, and type IV were 4 cases.

The Clinical Significance of BS Imaging Classification

In recent years, the BS imaging has generally been paid attention to by scholars at home and abroad. In the past, the BS imaging was the supplementary examination usually after clinical diagnosis, but nowadays, it changes: firstly, the BS imaging can be done to find suspected diagnosis, and then the further examination of clinical diagnosis is done to find the problem [7,15,16]. CT can find inferior or unable X-ray developing of I-IV lesions, especially the lesions in the vertebral bone lesions, destruction of facet joints, necrotic tissue in the intervertebral disc, periostitis reaction, and the images of paraspinal abscess or psoas abscess images. In this group, X-ray showed Only 12 cases' facet joints were damaged, and 9 cases showed the shadow of paraspinal soft tissue or psoas widened, while the CT showed more: 27 cases' facet joints were damaged, 26 cases had paraspinal or psoas abscess, and 8 cases were defined the scope of the vertebral body bigger lesions and whether the presence of necrotic bone. For the bigger abscesses, bone lesions and spinal instability, corresponding surgical treatment should be carried on in time including percutaneous and minimally invasive puncture treatment. Currently scholars at home and abroad generally accepted that MRI had the highest positive rate to examine BS, and should be the preferred method [1-17]. When MRI displayed the lesion, it has more advantages over CT, particularly for the discovery of spinal epidural abscess, destruction of intervertebral disc or inflammatory granulation tissue breaking into the canalis spinalis to compress the spinal cord, cauda equina, or nerve root. In the group, because the examination of X-ray and CT had their own limitations, they did not find the compression of spinal cord, cauda equina or nerve root, while the examination of MRI revealed 59 cases had the compression of spinal cord, cauda equine, or nerve root, so clinical debridement was adopted to relieve the compression spinal cord or cauda equina nerve root, and patients get cured. Thus, BS imaging classification has important reference value and guiding significance for developing strategies of clinical diagnosis and treatment and clinical evaluation [1-13,16-20].

The main method of treatment of BS at home and abroad is still drug therapy, and most of patients can be cured by non-surgical treatment [1,17,21,22]. In the group of 89 cases, based on the BS imaging classification, 59 cases who had ineffective drug therapy conformed to the following cases using debridement surgery with good result [2-4,16-20]: ① type I patients who had bigger vertebral lesions or destruction of joint so as to influence spinal instability; ② type II patients: whose intervertebral disc was damaged leading to intractable backache; ③ type IV patients: who had bigger paraspinal abscess or psoas abscess hard to absorb; ④ type V patients: who had spinal canal abscess or inflammatory granulation tissue breaking into the canalis spinalis to compress the spinal cord, cauda equina, or nerve root.

In addition, according to the BS imaging classification, the patients, with ineffective drug therapy, who had simple type II, type or type III accompanied by one of type II and type IV, could be cured by percutaneous and minimally invasive puncture treatment [2-4,19-23]. In this group, only five cases of simple type II whose intervertebral disc was damaged leading to intractable backache, were treated by minimally invasive percutaneous absorption dissection through cutting disc lesions; two cases of type IV and one case of type III accompanied by type IV were treated by minimally invasive percutaneous abscess suction catheter drainage; 8 cases of clinical follow-up of patients were cured. In the group of 89 cases, 67 cases were treated by surgical treatment, and the remaining 22 patients were cured by non-surgical, including 15 cases of type I, 2 cases of type II, 3 cases of type III, and 2 cases of type IV. Thus, according to the BS imaging classification, simply type I, type II, type III, and type IV can be cured by conservative treatment, while surgical treatment were operated when the state of the illness has evolved into the surgical indications.'

Problems and Prospects

Currently, BS has no unified standard of classification criteria. The method of classification in this paper only starting with the radiological, does not consider the clinical manifestations and results of laboratory test. Because the samples of patients only are the cases of own hospital with a relatively small amount, short observation time, and more single, and even less comprehensive index of classification, unavoidable selection mistake could be made. Therefore, pending further observation and study of a large sample, the BS classification will be perfected so as to provide valuable reference for clinical diagnosis and treatment.

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