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CASE REPORT

Use of PET/CT in the early diagnosis of implant related wound infection and avoidance of wound debridement

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Abstract
Purpose Delayed infections after spinal instrumentation typically require complete implant removal and extensive wound debridement due to the difficulties in establishing an early diagnosis. We report a case of occult late infection after posterior spinal instrumentation that was detected early using PET/CT and therefore was successfully treated with antibiotics alone.
Methods A 26-year-old woman who underwent posterior spinal instrumentation and fusion for scoliosis correction had superficial pseudomonal infection that healed with ceftazidime and levofloxacin and was admitted 4 months later with mild back pain. She had no fever and the surgical wound healed well. Laboratory tests were compatible with late infection but radiographs showed no signs of implant infection. The patient was suspected of having ongoing occult late infection and thus, underwent a PET/CT.
Results PET/CT revealed a significant pathological FDG uptake at the T5 vertebral body and the area surrounding proximal end of the T5 instrumentation. The maximal standardized uptake value (SUV) was 7.9 for the T5 vertebra and only 2.3 for the patient's liver, suggesting an infection pathology. A conclusive diagnosis of delayed onset infection after spinal instrumentation was established and the patient was immediately started on oral anti-pseudomonal treatment. The scoliosis correction was well maintained 10 months after the index surgery and she had no signs of implant infection.
Conclusions PET/CT provides detailed diagnostic information for occult infections in the absence of morphological changes and thus, is valuable for an early diagnosis of late infection after spinal instrumentation. It is possible to retain the instrumentation in the case of late infection, if early detection and efficacious treatment can be achieved timely.

Keywords Scoliosis · Posterior spinal fusion · Spinal instrumentation · Delayed infection · PET/CT · Diagnosis

Introduction

Delayed deep wound infections are low-grade infections that present after an asymptomatic interval of at least 3 months after spinal instrumentation surgery [1]. The reported incidence rate of delayed infection after spinal instrumentation ranges from 1.7 to 6.9 % [2, 3]. Although uncommon, late infection may result in serious consequences, such as back pain, additional surgical intervention [4], spinal pseudoarthrosis [5], and even loss of deformity correction [6].

Unlike acute infections which present immediately after surgery, late infections usually develop insidiously without fever or wound breakdown. In the early stages, mild back pain often is the only clinical sign. Establishment of diagnosis thus is typically delayed until the infection has spread along the instrumentation with apparent clinical

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manifestations such as a fluctuant mass, spontaneous drainage, or radiological loosening of the instrumentation [7]. Traditionally, late infections are treated aggressively with extensive wound debridement and prolonged courses of antibiotics [7–9], and ultimately implant removal. This is devastating, particularly when a solid spine fusion has not yet been achieved. An early detection of late infection, therefore, is essential to control the infection, which may win extra time for the spine to fuse, reduce the chance of pseudoarthrosis, and even avoid a second surgery.

It is, however, difficult to establish the diagnosis of late infection at the early stage. Blood tests, such as white blood cell (WBC) count, erythrocyte sedimentation rate (ESR) and C-reactive protein (CRP), are neither specific or sensitive [10]. Conventional imaging modalities, such as plain radiographs and computed tomography (CT), have limited value for an early diagnosis of late infection when structural changes of bone or soft tissues have yet to occur [11]. Magnetic resonance (MR) imaging may be another choice but its accuracy is substantially influenced by the metallic artifacts [8].

Radionuclide imaging may have important diagnostic and therapeutic impact on the management of occult primary spinal infections [12]. Yet, it is not a routine investigation for occult infections following spine instrumentation. We report a case of occult late infection after posterior spinal fusion for scoliosis correction that was detected early using ^{18}F-fluorodeoxyglucose (FDG) positron emission tomography/computed tomography (PET/CT). Because of the early detection, this patient was successfully treated with antibiotics alone, without the need for debridement surgery or implant removal.

Case report

A 26-year-old healthy woman presented with a progressive scoliosis deformity. The posteroanterior radiograph shows a lumbar curve (T11–L3) of 74 degrees and a thoracic curve (T6–T11) of 57 degrees (Fig. 1). She was diagnosed as having untreated adolescent idiopathic scoliosis (Lenke 6CN). She underwent deformity correction surgery with posterior spinal instrumentation and fusion from T5 to L4. The surgical drain was removed on post-operative day 2 and she was discharged on day 3 without wound problems.

Two weeks postoperatively, however, she returned to us for mild wound gapping ($\sim$1 cm) at the proximal end of the wound. There was some mild oozing of blood-stained fluid from the wound. Otherwise, there was no fever, back pain, local tenderness, erythema or foul-smelling discharge. WBC count, CRP and ESR tests were normal. Wound superficial infection was considered and the patient was given empirical antibiotic treatment with oral augmentin 375 mg three times daily. One week later, swab from the wound grew *Pseudomonas aeruginosa*. Intravenous ceftazidime and levofloxacin were administered for 1 week until the wound healed.

Four months after the spinal fusion surgery, the patient started to have pain at her upper back. The pain was mild but persistent, with a visual analog scale of 2–3 out of 10. She had no fever or neurological deficit and the surgical wound was healed without any erythema, boggy swelling or tenderness. Laboratory tests showed a normal WBC count (7.64×10^9/l) with 85 % of neutrophils, normal CRP (4.14 mg/dl) and elevated ESR (75 mm/h). Radiographs showed that the instrumentation was in situ with no signs of failure including screw pull-out or loosening. There was no endplate sclerosis or erosion, no obvious bony lysis or lucencies around the pedicle screws (Fig. 2).

The patient was suspected of having ongoing occult late infection. Yet, a definitive diagnosis had not been achieved due to the lack of substantial evidence. The patient underwent a FDG PET/CT scanning to identify a possible infection focus. There was a significant pathological FDG uptake at the vertebral body of T5 and the area surrounding the proximal end of the instrumented rods (Fig. 3). The increased uptake was more obvious at the distal end of right T5 pedicle screw, with a maximal standardized uptake value (SUV) of 7.9 (The SUV for her liver was 2.3). Subtle soft tissue thickening was noted at the proximal surgical site but there was no overt fluid collection seen at the paraspinal region. There was no focal bone destruction seen in the spine and no other areas of pathologic FDG uptake were identified. Overall features suggested infective changes around the proximal end of spinal instrumentation.

A clear diagnosis of delayed onset infection after spinal instrumentation was established. The patient started combined antibiotics treatment with intravenous piperacillin and tazobactam. The patient's back pain disappeared 1 week later, together with improved ESR. She was switched to oral levofloxacin 750 mg daily for 3 months due to antibiotic-related rash and neutropenia.

The patient was further followed-up for another 6 months after completion of antibiotics. She had no back pain, malaise or wound problems. There was no local tenderness, erythema or discharge at the upper end of the surgical wound. Blood tests have completely normalized and radiographs showed the scoliosis correction was well maintained, with no signs of screw loosening.

Discussion

Delayed infection is caused by seeding of low-virulent bacteria through a surgical or hematogenous approach at the instrumented surgical site that is activated after a latent

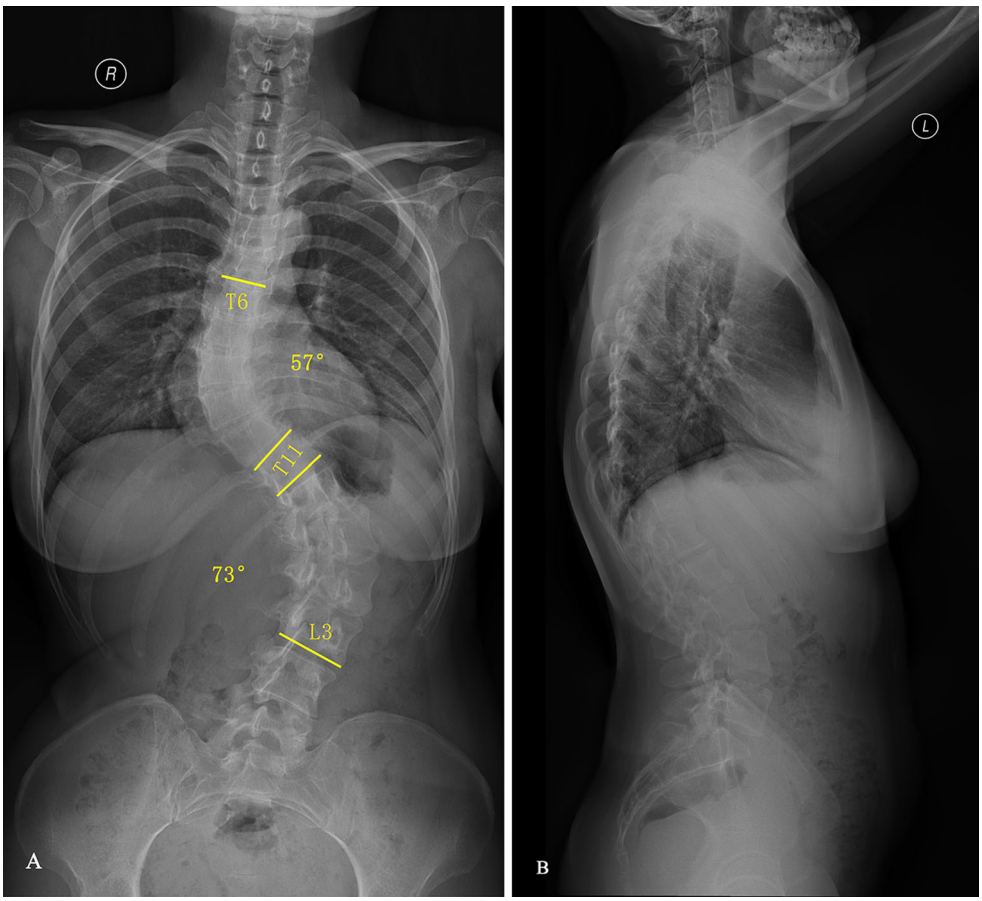

Fig. 1 Pre-operative radiographs showing a lumbar curve (T11–L3) of 74 degrees and a thoracic curve (T6–T11) of 57 degrees. The idiopathic scoliosis was classified as Lenke 6CN

period of several months or years [13]. As a low-grade infection, fever and wound problems are typically absent in the early stage. As such, diagnosis is usually delayed until there is widespread infection along the instrumentation with resultant fluid collection or wound discharge. During the chronic process of late infections, a glycocalyx may form around the implants, which shields bacteria and impairs antibiotic penetration [8, 13]. As a result, complete implant removal and throughout debridement are typically needed to control the infection [14]. This poses a difficult dilemma to the surgeon when the spine has not been fused. An early detection of suspicious late infections and prompt treatment, for example before the glycocalyx is formed, potentially can allow retention of the implants and avoid consequent complications such as pseudoarthrosis and loss of deformity correction.

The diagnosis of late infection after spine instrumentation can be challenging. Common serology studies, such as leukocyte count, ESR and CRP, are non-specific and are not helpful in a definitive diagnosis [10]. For evaluation of suspected late infections, plain radiographs and CT have low sensitivity and specificity in the early stage of infection [11]. These investigations can only detect infections when significant morphological changes occur, such as screw loosening or substantial bone resorption around the screw [11]. The value of MR in the early diagnosis of late infection after spinal instrumentation remains unclear as its accuracy is impaired by metallic artifacts and postsurgical changes of the bone and soft tissues [15].

PET/CT imaging may be a valuable alternative diagnostic tool for the early diagnosis of suspicious late infections. As FDG enters the cells via glucose transporters, inflamed or infected tissues accumulate FDG more avidly than normal tissues due to their increased glucose consumption rate. Therefore, PET/CT is based on changes in cell metabolism but not changes in morphology to detect a pathology. It is hence able to detect infectious lesions far before bony structural destruction occurred. At the same time, PET/CT is a high-resolution tomography technique which is able to precisely localize abnormalities and produce images of high spatial and contrast resolution [12]. As FDG accumulates in activated macrophages, the predominant cell type in chronic infections, PET/CT is also useful for diagnosing chronic and low-grade infections [16, 17]. In diagnosing musculoskeletal infections, PET/CT is nearly 100 % sensitive and its specificity and accuracy are typically greater than 90 % [18–20]. Moreover, PET/CT is able to quantify the rate of FDG uptake, such as the

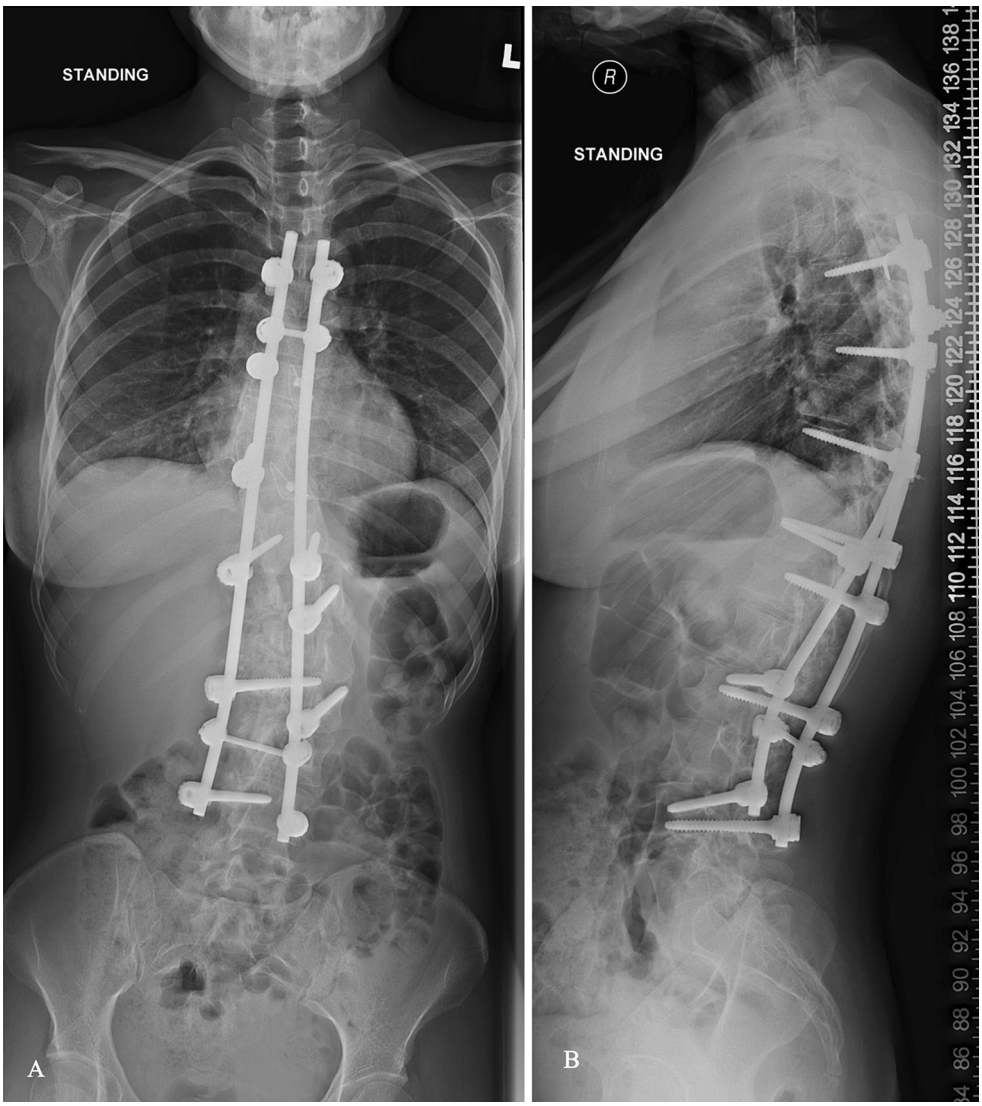

Fig. 2 Four-month postoperative radiographs when the patient had back pain. Overall, the radiographs were normal. There were no signs of instrumentation failure, screw pull-out, and screw loosening. There were also no endplate sclerosis or erosion, bony lysis or lucencies around the pedicle screws

semiquantitative SUV used in our case, to differentiate infections from non-infectious conditions including bone healing and surgical interruption. In addition, PET/CT is particularly useful for diagnosing metallic implant-associated chronic infections as the imaging will not be affected by metal implants [19].

In our case, PET/CT detected an unusually high uptake of FDG at the site around the T5 screw and rod nearby, which was highly suggestive of an infection. The diagnosis of occult delayed infection around the instrumentation was confidently established and antibiotic treatment was started promptly. It was uncertain, however, whether the infection was a recurrence of the previous wound infection or a de novo delayed infection. A recurrence is suspicious as the patient was successfully managed with an antibiotic regimen that was based upon the previous wound cultures. Nevertheless, the PET/CT clearly delineated the extent of infection, which was localized, without significant fluid collection and bony destruction. These findings were valuable to support our decision to treat the patient conservatively instead of using traditional strategies including surgical implant removal, debridement, or re-instrumentation [14, 21]. Although it is not known whether the infection will recur in the long-term, the early detection of infection and antibiotic treatment do substantially contribute to the well-controlled infection to date and thus won the patient adequate time for spinal fusion. Hence, PET/CT has valuable diagnostic and therapeutic significance in managing late onset infection after spine instrumentation surgery.

Although clinically informative and valuable, we are not suggesting routine use of the PET/CT for the diagnosis of infection after spinal instrumentation. For the vast majority of infections, a good clinical examination, serology and microbiology studies are adequate to establish the diagnosis. Rather, PET/CT can be used as an alternative when the clinical signs are atypical and an occult infection is

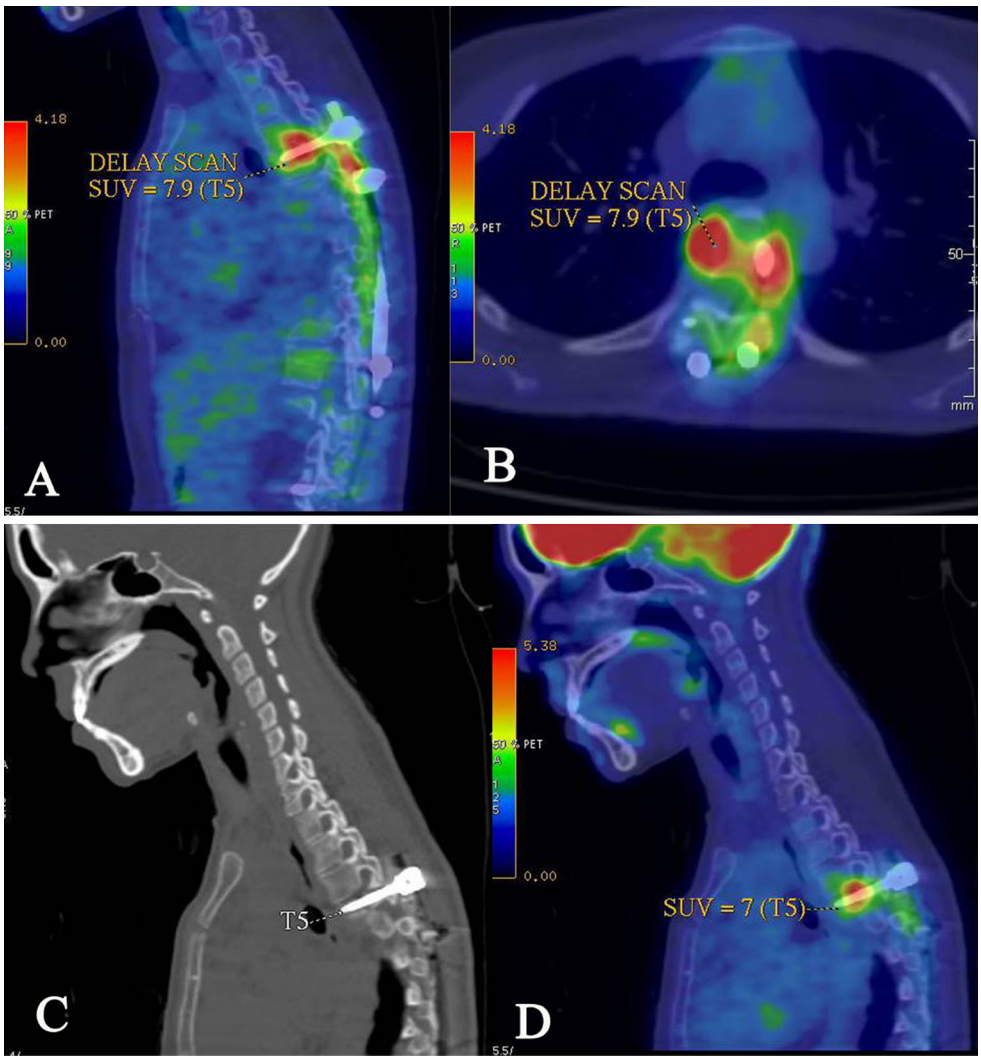

Fig. 3 FDG PET/CT study for the patient who was suspected of delayed low-virulence infection. **a** Sagittal PET/CT image showed that there was a significantly increased FDG uptake along the T5 right pedicle screw to the proximal end of the right rod. While the standardized uptake value (SUV) for the liver was 2.3 in this patient, the maximal SUV for T5 vertebral body was 7.9, which was highly suggestive of a focal infection. **b** Although there was no pedicle screw inserted at the left side, the increased uptake was obvious at both sides of T5 vertebral body, suggesting the whole vertebral body was involved. Subtle soft tissue thickening was noted at the proximal surgical site but there was no overt fluid collection at the paraspinal region. **c** CT sagittal images showed there was no focal bone destruction or halo sign in the T5 vertebral body; but **d** sagittal PET image of the same plane clearly demonstrated there was increased pathologic FDG activity around the T5 pedicle screw with a mean SUV of 7.5

suspected. It may also guide the location for biopsy in cases without a clear infective focus. We should bear in mind that PET/CT exposes patients to high doses of radiation, which is estimated to be 5–13 times the average effective dose from background radiation over 1 year [22]. Such a high dose of radiation may induce cancer risk, particularly in young patients [23]. Also, PET/CT is an expensive modality which may not be readily available. To minimize the influence from the increased FDG uptake due to surgical intervention, perhaps a post-operative interval of 3 to 4 months is a good timing to have a PET/CT scan [16, 17] for patients who are suspected of occult infections.

Conclusion

PET/CT provides detailed diagnostic information, such as the site and the degree, for occult infections in the absence of morphological changes, and therefore, is valuable for an early diagnosis of occult delayed infections. For spinal infection of late onset, it is possible to retain the instrumentation, if early detection and treatment are achieved in time.

Conflict of interest None of the authors has any potential conflict of interest.

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