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Epidemiological and clinical features of pyogenic spondylodiscitis

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Abstract. – Pyogenic spondylodiscitis (PS) is an uncommon but important infection, that represents 3-5% of all cases of osteomyelitis. The annual incidence in Europe has been estimated to be from 0.4 to 2.4/100,000. A has been reported, with peaks at age less than 20 years and in the group aged 50-70 years. The incidence of PS seems to be increasing in the last years as a result of the higher life expectancy of older patients with chronic debilitating diseases, the rise in the prevalence of immunosuppressed patients, intravenous drug abuse, and the increase in spinal instrumentation and surgery.

PS is in most cases a hematogenous infection. *Staphylococcus aureus* is the most frequent causative microorganism, accounting for about one half of the cases of PS. Gram-negative rods are causative agents in 7-33% of PS cases. Coagulase-negative staphylococci (CoNS) have been reported in 5-16% of cases. *Staphylococcus epidermidis* is often related to post-operative infections and intracardiac device-related bacteremia.

Unremitting back pain, characteristically worsening during the night, is the most common presenting symptom, followed by fever that is present in about one half of the cases. The mortality of PS ranges from 0 to 11%. In a significant number of cases, recrudescence, residual neurological defects or persistent pain may occur.

Key words:

Spondylodiscitis, Etiology, Epidemiology, Diagnosis, Outcome.

Introduction

Pyogenic spondylodiscitis (PS) is an uncommon but important infection. The incidence has increased in the last years, as a result of the higher life expectancy of older patients with chronic debilitating diseases, the rise in the prevalence of immunosuppressed patients and intravenous drug abusers, and the increase in spinal surgery.

PS is often an indolent disease; consequently, the time from the onset of symptoms and diagnosis can be very long (up to 12 months), thus affecting outcome.

This article is intended to discuss certain aspects of the approach to PS, focusing on epidemiology, diagnosis, and outcomes.

Epidemiology

PS represents 2-5%[1,2] of all cases of osteomyelitis. PS is more common in patients aged over 50 years [3]. In pediatric age it represents only 1-2% of bone infections. In many studies a bimodal age distribution is reported, with peaks at age less than 20 years and in the group aged 50-70 years[1-3,5-8]. The incidence of spondylodiscitis ranges from 4 to 24 per million per year in developed countries[9,10]. The annual incidence in Europe has been estimated to be from 0.4 to 2.4/100,000[1,11], with the variability depending on the inclusion criteria (immigrant people, children, drug abusers) of few studies covering limited areas. Vertebral osteomyelitis is more common in male patients, with a male to female ratio of 1.5-2:1[1,7,12,13]. This gender predominance is not observed below the age of 20 years, but it dramatically increases over 80 years of age, probably because of a higher frequency of comorbidities in men aged >60 years[1,13]. The increased incidence of PS in the last years[8,11,12] may also be due to an improvement in diagnostic sensitivity[7,11,12,14,15]. In two Danish studies from the same population there was an increase in the prevalence of vertebral osteomyelitis with *Staphylococcus aureus* septicemia, doubling the cases from 1.1% to 2.2% in a ten years period[14,16]. In other reports the increase of PS cases is attributed to intravenous

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drug use[17], diabetes mellitus, long term steroid use, to the rise in health-care-associated infections[18], chronic renal or liver diseases, increase of the immunosuppressed subjects, ageing population[12,19] and, especially, spinal surgery[20]. The reported incidence of post-operative PS ranges from 0.5% to 18.8% due to significant variation in many factors (i.e. case complexity, use of instrumentation, and surgical approach).

Pathogenesis

PS is in most cases a hematogenous infection. The most likely route of infection is arterial. The spinal arteries bifurcate to supply the adjacent vertebrae, so that the infectious process often involves two bony segments. In adults, the intervertebral disc is avascular since the spinal arteries are terminal arteries. Thus, a septic embolus may produce bony ischemia and infarction, with subsequent bone destruction, extension to the contiguous disc space, instability and spread to the paravertebral soft tissues, which define the characteristic features of PS. In children, on the contrary, there are extensive intra-discal anostomosis. Therefore, septic emboli do not produce bony infarcts, limiting the infection to the disc.

PS is, thus, frequently the consequence of hematogenous seeding of distant infectious foci. Typically this may occur in the presence of bacterial endocarditis, due to persistent bacteremia. The association between PS and endocarditis is well established. Up to one third of the patients with PS may be diagnosed with endocarditis, whereas in 2-20% of patients with endocarditis may be complicated by spondylodiscitis[21].

Although less often than by the arterial route, also the venous circulation may play a role in the pathogenesis of PS. A retrograde flow may occur from the pelvic plexus to the paravartebral plexus, which is more likely to occur when there is an increased intra-abdominal pressure. In such circumstances an infection of the pelvic organs can spread to the spine[22,23]. More rarely, a retrograde venous flow may transmit an infection from the retropharyngeal space to the vertebrae, through the retropharyngeal venous plexus.

Less common than hematogenous spread, but of growing importance in the last few years, is the development of PS by direct inoculation, following spinal surgery, epidural procedures or lumbar puncture. Of particular concern are the infections that follow the implant of prosthetic material. In some series, the proportion of PS related to spinal surgery or procedures exceeds 20% of all the cases[24,25].

Lumbar vertebrae are most frequently affected in PS, followed by the thoracic and the cervical area. In a significant number of cases a multifocal involvement may be observed.

Microbiology

Microbial agents of PS reported in the main case series and reviews are reported in Table I. *Staphylococcus (S.) aureus* is the most frequent causative microorganism accounting for half of the cases of PS. The range described in different studies varies from 20% to 84%[2,9,25-33].

The large majority of community-acquired strains are susceptible to methicillin; nevertheless colonization with methicillin-resistant *Staphylococcus aureus* (MRSA) strains is becoming more and more frequent.

Gram-negative rods are causative agents in 7-33% of PS cases[9,25-28,30,32]. The most frequent species are enterobacteriaceae, e.g. *Escherichia coli*, *Proteus spp*., *Klebsiella spp*, *Enterobacter spp* and *Pseudomonas (P.) aeruginosa*. These microorganisms are often associated with urinary or gastrointestinal tract infections, older age, immune suppression and diabetes[11]. *P. aeruginosa* is mostly associated to intravenous drug use, although *S. aureus* remains the main causative pathogen in this population[19,35]. Coagulase-negative staphylococci (CoNS) are reported in 5-16%. of pyogenic cases[26-28,30,32,33]. *S. epidermidis* is the most frequent pathogen involved and it's often related to post-operative infections and intracardiac device-related bacteremia[24,36]. Among CoNS, *S. lugdunensis* is a virulent coagulase-negative *Staphylococcus* that behaves like *S. aureus*, and is less frequently isolated in PS[37].

Streptococci and Enterococci have also been reported as causes of PS in 5-20% of cases[25,26]. Streptococci may be isolated in association with a dental portal of entry or endocarditis. Isolation of *Streptococcus pneumonia* is rare[38].

Anarobes account for 3% of PS[13]: *Propionibacterium acnes* is linked with post-operative discitis[39] and with implanted material[40], but it has been observed also in native infections[13]. *Bacteroides fragilis* and other anaerobes are more common in diabetic patients and have been associated with pelvic or intra-abdominal infections[26,41].

Table II. Pyogenic spondylodiscitis: relative frequency of causative microorganisms in 10 different studies.

	Carragee[19]	Colmenero[3]	D'Agostino[33]	Grammatico[1]	Hadja-pavlou[26]	Jimenez-Mejias[24]	Mc Henry[48]	Nolla[43]	Pigrau[21]	Sapico[7]
N. of isolations	102 (%)	72 (%)	65 (%)	1139 (%)	74 (%)	113 (%)	255 (%)	64 (%)	91 (%)	154 (%)
S. aureus	40 (39)	29 (40)	28 (43)	377 (33)	44 (59)	47 (42)	123 (48)	23 (36)	27 (42)	85 (55)
CoNS	18 (18)	9 (12)	8 (12)	257 (26)	20 (27)	14 (12)	17 (7)	2 (3)	3 (3)	5 (3)
Streptococcus spp	18 (18)	2 (3)	7 (11)	223 (13)	20 (27)	1 (1)	24 (9)	12 (19)	22 (24)	13 (9)
Enterococcus spp.	/	/	/	/	4 (5)	/	/	1 (2)	4 (4)	/
E. coli	7 (7)	8 (11)	/	/	3 (4)	12 (11)	30 (12)	15 (23)	14 (15)	16 (10)
P. aeruginosa	1 (1)	7 (10)	8 (12)	/	4 (5)	10 (9)	13 (5)	3 (5)	1 (1)	9 (6)
Other gram negative bacilli	/	3 (4)	/	/	3 (4)	8 (7)	16 (6)	7 (11)	6 (6)	21 (14)
Anaerobic	4 (4)	5 (7)	/	/	3 (4)	10 (9)	2 (1)	1 (2)	0	5 (3)
Candida spp.	1 (1)	5 (7)	4 (6)	8 (1)	0	/	2 (1)	0	3 (3)	/
Polymicrobial	12 (12)	3 (4)	/	37 (3)	24 (32)	6 (5)	20 (8)	0	0	4 (2)
Other	2 (2)	1 (1)	10 (15)	139 (12)	4 (5)	11 (10)	/	2 (3)	1 (1)	/

Fungi are rarely involved in vertebral infections, with *Candida albicans* accounting for 1-2% of all cases[2], although in a recent prospective study a higher proportion is reported[33]. Risk factors for candidaemia and spinal seeding are immunosuppression, diabetes, intravenous drug use, surgical intervention, prolonged use of indwelling vascular catheters, administration of broad-spectrum antibiotics and hospitalization in intensive care.

Less than 10% of spondylodiscitis are polimicrobial infections[12,13]. In two different retrospective studies based on reviewed medical records with a discharge diagnosis of spondylodiscitis, a proportion of 32%[42] and 34%[1] was reported, respectively. In some prospective studies the frequency of culture-negative spinal infections ranged from 21% to 34%[26,32,33,42].

Clinical Presentation

PS is often an indolent disease and the time from the onset of symptoms and diagnosis may be very long. In studies reporting this particular information, the time-lapse to diagnosis ranges from 11 days to 12 months[18,30,42-45]. Unremitting back pain, characteristically worsening during the night, is the most common presenting symptom, followed by fever that is present in about one half of the cases[2,12,46]. An epidural abscess should be suspected when pain is particularly severe. Abscess formation complicates more commonly cervical spondylodiscitis[26]. When the abscess involves the cervical spine, the patient can experience a severe cervical rigidity, dysphagia or torticollis. In the case of thoracic abscess, symptoms are localized at the legs. Abscesses of the lumbar spine can spread through the ischiatic foramen and involve gluteus muscles; when lower lumbosacral roots are involved the "cauda syndrome" can appear. Sinus formation can be the result of a long-standing unrecognized infection.

Many patients report a febrile illness weeks before the onset of back pain, followed by a long period of defervescence. This may be related to the initial hematogenous seeding of the spine, an information that may be useful to establish the time interval from the onset of the disease. Neurological symptoms are present in about one third of the cases, ranging from mild dysestesia or weakness to severe paralysis, sphincter loss and radiculopathy[12,21]. When the delay in diagnosis is particularly long, a significant proportion of patients may experience weight loss.

Given the aspecific onset of PS, which is dominated by cervical or back pain, the differential diagnosis should include disc herniation, metastatic seeding, inflammatory or degenerative spinal disease.

Diagnosis

Once spondylodiscitis is suspected on clinical and radiological basis, blood cultures should be obtained, regardless of the presence of fever. In a systematic review of studies on PS, positive blood cultures were reported in 30-78% of cases[12]. It has been reported that diagnostic sensitivity of cultures may be improved if they are taken shortly after discal or vertebral biopsy[47].

Because of the importance of bacteriological diagnosis in PS, if blood cultures are negative, a CT-guided needle biopsy or a surgical biopsy is warranted. Although more invasive, the biopsy has a better diagnostic yield than blood cultures, ranging from 47 to 100%[12]. Histopathological specimens should also be obtained from biopsy, in order to distinguish between contamination and infection or to detect the presence of granulomas, suggesting the presence of tuberculosis or brucellosis. C-reactive protein levels and erythrocyte sedimentation rate are almost constantly elevated in the course of PS, both spontaneous and post-surgical. C-reactive protein is a sensitive marker of infection and it is more closely related to the response to treatment.

Outcome

The mortality of PS ranges from 0 to 11%[2]. In a significant number of cases, recrudescence, residual neurological defects or persistent pain may occur. Interestingly, in one study patients treated only with antibiotics and immobilization reported recurrent back pain more frequently than patients treated surgically (64% vs 26.3%)[26].

Adverse outcome, defined as death or disability, was reported to be independently associated with delay in diagnosis greater than 2 months, paralysis or motor weakness and hospital acquisition[48].

Infection-related mortality of PS was also reported to be associated with *S. aureus* bacteremia[21].

Conclusions

PS is an uncommon diagnosis, but its frequency is expected to rise, due to the increase of the susceptible populations and of spinal surgical procedures. The insidious presentation of PS requires a high level of suspicion in all patients that present with back pain, inconstant fever, and laboratory markers of inflammation.

The most frequently affected population is that of elderly patients, who more often experience multiple co-morbidities and frequent contacts with health care institutions. Hence, drug-resistant organisms, particularly MRSA, are expected to be of growing importance in the future. Patients with PS should be investigated for the presence of endocarditis not only if risk factors are present or when clinically suspected, but also if the infecting agent is *Streptococcus spp.* or *Staphylococcus spp.* Microbiological diagnosis must be considered a priority in all patients with suspected PS, in order to start an appropriate treatment only when the etiologic agent is identified. If blood cultures are negative, CT-guided or surgical biopsy is recommended. To improve the diagnostic yield, a useful procedure could be also to obtain blood cultures shortly after the biopsy.

References

1) Grammatico L, Baron S, Rusch E, Lepage B, Surer N, Desenclos JC, Besnier JM. Epidemiology of vertebral osteomyelitis (VO) in France: analysis of hospital-discharge data 2002-2003. Epidemiol Infect 2008; 136: 653-660.
2) Gouliouris T, Aliyu SH, Brown NM. Spondylodiscitis: update on diagnosis and management. J Antimicrob Chemother 2010; 65: 11-24.
3) Sobottke R, Seifert H, Fätkenheuer G, Schmidt M, Gossmann A, Eysel P. Current diagnosis and treatment of spondylodiscitis. Dtsch Arztebl Int 2008; 105: 181-187.
4) Digby JM, Kersley JB. Pyogenic non-tuberculous spinal infection: an analysis of thirty cases. J Bone Joint Surg Br 1979; 61: 47-55.
5) Krogsgaard MR, Wagn P, Bengtsson J. Epidemiology of acute vertebral osteomyelitis in Denmark: 137 cases in Denmark 1978-1982, compared to cases reported to the National Patient Register 1991-1993. Acta Orthop Scand 1998; 69: 513-517.
6) Malawski SK, Lukawski S. Pyogenic infection of the spine. Clin Orthop Relat Res 1991; 272: 58-66.

7) Sapico FL, Montgomerie JZ. Pyogenic vertebral osteomyelitis: report of nine cases and review of the literature. Rev Infect Dis 1979; 1: 754-776.

8) Gasbarrini AL, Bertoldi E, Mazzetti M, Fini L, Terzi S, Gonella F, Mirabile L, Barbanti Bròdano G, Furno A, Gasbarrini A, Boriani S. Clinical features, diagnostic and therapeutic approaches to haematogenous vertebral osteomyelitis. Eur Rev Med Pharmacol Sci 2005; 9: 53-66.

9) Chelsom J, Solberg CO. Vertebral osteomyelitis at a Norwegian university hospital 1987-97: clinical features, laboratory findings and outcome. Scand J Infect Dis 1998; 30: 147-151.

10) Joughin E, McDougall C, Parfitt C, Yong-Hing K, Kirkaldy-Willis WH. Causes and clinical management of vertebral osteomyelitis in Saskatchewan. Spine (Phila Pa 1976) 1991; 16: 261-264.

11) Cottle L, Riordan T. Infectious spondylodiscitis. J Infect 2008; 56: 401-412.

12) Mylona E, Samarkos M, Kakalou E, Fanourgiakis P, Skoutelis A. Pyogenic vertebral osteomyelitis: a systematic review of clinical characteristics. Semin Arthritis Rheum 2009; 39: 10-17.

13) Skaf GS, Domloj NT, Fehlings MG, Bouclaous CH, Sabbagh AS, Kanafani ZA, Kanj SS. Pyogenic spondylodiscitis: an overview. J Infect Public Health 2010; 3: 5-16.

14) Jensen AG, Espersen F, Skinhøj P, Rosdahl VT, Frimodt-Møller N. Increasing frequency of vertebral osteomyelitis following Staphylococcus aureus bacteraemia in Denmark 1980-1990. J Infect 1997; 34: 113-118.

15) Waldvogel FA, Papageorgiou PS. Osteomyelitis: the past decade. N Engl J Med 1980; 303: 360-370.

16) Jensen AG, Espersen F, Skinhøj P, Frimodt-Møller N. Bacteremic Staphylococcus aureus spondylitis. Arch Intern Med 1998; 158: 509-517.

17) Musher DM, Thorsteinsson SB, Minuth JN, Luchi RJ. Vertebral osteomyelitis. Still a diagnostic pitfall. Arch Intern Med 1976; 136: 105-110.

18) Torda AJ, Gottlieb T, Bradbury R. Pyogenic vertebral osteomyelitis: analysis of 20 cases and review. Clin Infect Dis 1995; 20: 320-328.

19) Carragee EJ. Pyogenic vertebral osteomyelitis. J Bone Joint Surg Am 1997; 79: 874-880.

20) Deyo RA, Nachemson A, Mirza SK. Spinal-fusion surgery–the case for restraint. N Engl J Med 2004; 350: 722-726.

21) Pigrau C, Almirante B, Flores X, Falco V, Rodríguez D, Gasser I, Villanueva C, Pahissa A. Spontaneous pyogenic vertebral osteomyelitis and endocarditis: incidence, risk factors, and outcome. Am J Med 2005; 118: 1287.

22) Tyrrell PN, Cassar-Pullicino VN, McCall IW. Spinal infection. Eur Radiol. 1999; 9: 1066-1077.

23) Govender S. Spinal infections. J Bone Joint Surg Br 2005; 87: 1454-1458.

24) Jiménez-Mejías ME, de Dios Colmenero J, Sánchez-Lora FJ, Palomino-Nicás J, Reguera JM, García de la Heras J, García-Ordoñez MA, Pachón J. Postoperative spondylodiskitis: etiology, clinical findings, prognosis, and comparison with nonoperative pyogenic spondylodiskitis. Clin Infect Dis 1999; 29: 339-345.

25) Legrand E, Flipo RM, Guggenbuhl P, Masson C, Maillefert JF, Soubrier M, Noël E, Saraux A, Di Fazano CS, Sibilia J, Goupille P, Chevalie X, Cantagrel A, Conrozier T, Ravaud P, Lioté F; Rheumatology Network Organization. Management of nontuberculous infectious discitis. Treatments used in 110 patients admitted to 12 teaching hospitals in France. Joint Bone Spine 2001; 68: 504-509.

26) Hadjipavlou AG, Mader JT, Necessary JT, Muffoletto AJ. Haematogenous pyogenic spinal infections and their surgical management. Spine 2000; 25: 1668-1679.

27) Turunc T, Demiroglu YZ, Uncu H, Colakoglu S, Arslan H. A comparative analysis of tuberculous, brucellar and pyogenic spontaneous spondylodiscitis patients. J Infect 2007; 55: 158-163.

28) Euba G, Narváez JA, Nolla JM, Murillo O, Narváez J, Gómez-Vaquero C, Ariza J. Long-term clinical and radiological magnetic resonance imaging outcome of abscess-associated spontaneous pyogenic vertebral osteomyelitis under conservative management. Semin Arthritis Rheum 2008; 38: 28-40.

29) Beronius M, Bergman B, Andersson R. Vertebral osteomyelitis in Göteborg, Sweden: a retrospective study of patients during 1990-95. Scand J Infect Dis 2001; 33: 527-532.

30) Colmenero JD, Jiménez-Mejías ME, Sánchez-Lora FJ, Reguera JM, Palomino-Nicás J, Martos F, García de las Heras J, Pachón J. Pyogenic, tuberculous, and brucellar vertebral osteomyelitis: a descriptive and comparative study of 219 cases. Ann Rheum Dis 1997; 56: 709-715.

31) Hopkinson N, Stevenson J, Benjamin S. A case ascertainment study of septic discitis: clinical, microbiological and radiological features. QJM 2001; 94: 465-470.

32) Bhavan KP, Marschall J, Olsen MA, Fraser VJ, Wright NM, Warren DK. The epidemiology of hematogenous vertebral osteomyelitis: a cohort study in a tertiary care hospital. BMC Infect Dis 2010; 10: 158.

33) D'Agostino C, Scorzolini L, Massetti AP, Carnevalini M, D'Ettorre G, Venditti M, Vullo V, Orsi GB. A seven-year prospective study on spondylodiscitis: epidemiological and microbiological features. Infection 2010; 38: 102-107.

34) Patzakis MJ, Rao S, Wilkins J, Moore TM, Harvey PJ. Analysis of 61 cases of vertebral osteomyelitis. Clin Orthop Relat Res 1991; 264: 178-183.

35) Perronne C, Saba J, Behloul Z, Salmon-Céron D, Leport C, Vildé JL, Kahn MF. Pyogenic and tuberculous spondylodiskitis (vertebral osteomyelitis) in 80 adult patients. Clin Infect Dis 1994; 19: 746-750.

36) Bucher E, Trampuz A, Donati L, Zimmerli W. Spondylodiscitis associated with bacteraemia due to coagulase-negative staphylococci. Eur J Clin Microbiol Infect Dis 2000; 19: 118-120.

37) Camacho M, Guis S, Mattei JP, Costello R, Roudier J. Three-year outcome in a patient with Staphylococcus lugdunensis discitis. Joint Bone Spine 2002; 69: 85-87.

38) Turner DP, Weston VC, Ispahani P Streptococcus pneumoniae spinal infection in Nottingham, United Kingdom: not a rare event. Clin Infect Dis 1999; 28: 873-881.

39) Dufour V, Feydy A, Rillardon L, Redondo A, Le Page L, Bert F, Belmatoug N, Fantin B. Comparative study of postoperative and spontaneous pyogenic spondylodiscitis. Semin Arthritis Rheum 2005; 34: 766-771.

40) Uçkay I, Dinh A, Vauthey L, Asseray N, Passuti N, Rottman M, Biziragusenyuka J, Riché A, Rohner P, Wendling D, Mammou S, Stern R, Hoffmeyer P, Bernard L. Spondylodiscitis due to Propionibacterium acnes: report of twenty-nine cases and a review of the literature. Clin Microbiol Infect 2010; 16: 353-358.

41) Saeed MU, Mariani P, Martin C, Smego RA Jr, Potti A, Tight R, Thiege D. Anaerobic spondylodiscitis: case series and systematic review. South Med J 2005; 98: 144-148.

42) Luzzati R, Giacomazzi D, Danzi MC, Tacconi L, Concia E, Vento S. Diagnosis, management and outcome of clinically suspected spinal infection. J Infect 2009; 58: 259-265.

43) Nolla JM, Ariza J, Gómez-Vaquero C, Fiter J, Bermejo J, Valverde J, Escofet DR, Gudiol F. Spontaneous pyogenic vertebral osteomyelitis in non drug users. Semin Arthritis Rheum 2002; 31: 271-278.

44) Bateman JL, Pevzner MM. Spinal osteomyelitis: a review of 10 years' experience. Orthopedics 1995; 18: 561-565.

45) Osenbach RK, Hitchon PW, Menezes AH. Diagnosis and management of pyogenic vertebral osteomyelitis in adults. Surg Neurol 1990; 33: 266-275.

46) Wirtz DC, Genius I, Wildberger JE, Adam G, Zilkens KW, Niethard FU. Diagnostic and therapeutic management of lumbar and thoracic spondylodiscitis: an evaluation of 59 cases. Arch Orthop Trauma Surg 2000; 120: 245-251.

47) Cherasse A, Martin D, Tavernier C, Maillefert JF. Are blood cultures performed after disco-vertebral biopsy useful in patients with pyogenic infective spondylitis? Rheumatology 2003; 42: 913.

48) McHenry MC, Easley KA, Locker GA. Vertebral osteomyelitis: long-term outcome for 253 patients from 7 Cleveland-area hospitals. Clin Infect Dis 2002; 34: 1342-1350.