International Journal of Infectious Diseases 81 (2019) 17–24

Contents lists available at ScienceDirect

International Journal of Infectious Diseases

journal homepage: www.elsevier.com/locate/ijid

Review

Listeriosis in mainland China: A systematic review

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ARTICLE INFO

Article history:
Received 19 September 2018
Received in revised form 26 December 2018
Accepted 5 January 2019
Corresponding Editor: Eskild Petersen, Aarhus, Denmark

Keywords:
Listeriosis
Foodborne disease
China
Review

ABSTRACT

Objective: The aim of this study was to conduct a systematic review to better understand the epidemiological and clinical characteristics of listeriosis patients in mainland China.
Methods: The six most widely used Chinese and English language databases were searched. The records of patients with listeriosis in mainland China reported during the years 2011–2017 were extracted. The clinical data of patients and information on clinical isolates of Listeria were collected and analyzed.
Results: In total, 136 records were identified, reporting 562 patients with listeriosis. The number of patients was much higher than that reported in the previous decade. The 227 non-perinatal listeriosis patients included had a mortality rate of 23.78%. Of the 231 perinatal listeriosis patients, 32.68% resulted in abortion and/or newborn death. All listeriosis cases were reported as being sporadic. The listeriosis was traced to infection via a meat product in only three patients, while 33.12% were healthcare-associated infections.
Conclusions: The number of patients with listeriosis in mainland China may have been underestimated previously. Perinatal cases in mainland China account for a much higher proportion than is usually described. Considering the high number of listeriosis patients in China, a comprehensive monitoring system for Listeria is urgently needed.

Contents

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https://doi.org/10.1016/j.ijid.2019.01.007

Introduction

Listeria monocytogenes is a Gram-positive facultative intracellular bacterium that can infect people via food contamination and cause human listeriosis (Radoshevich and Cossart, 2018). The clinical manifestations of listeriosis vary among individuals, from moderate focal infections such as diarrhea to severe infections such as septicemia, meningitis, and abortion or newborn listeriosis in perinatal patients, and the mortality rate is relatively high (20–40%) (Muñoz-Gallego et al., 2017; Salama et al., 2018). Although most reported listeriosis cases have been sporadic, many outbreaks have been reported, including outbreaks due to contaminated apples, cheese, cantaloupes, meat, and other food sources (Ottesen et al., 2016). In China, outbreaks are rare, and relevant contaminants have not been reported clearly. However, the contamination rate of Listeria in retail food sold in China is relatively high (Wu et al., 2016), indicating a high potential risk of listeriosis in the Chinese population.

The incidence of listeriosis has been estimated at approximately three to six patients per one million population per year globally (de Noordhout et al., 2014). Feng et al. (2013) reviewed the cases of listeriosis patients reported in China from 1964 to 2010 and found that there were 147 sporadic cases and 82 outbreak cases, with mortality rates of 26% in overall listeriosis and 46% in neonatal listeriosis. Wang et al. (2013) investigated listeriosis at a tertiary hospital and found a high prevalence of healthcare-associated listeriosis among adult patients.

The long incubation period and non-specific clinical manifestations make it difficult to diagnose listeriosis in a timely manner (Choi et al., 2018). Therefore, it is important to determine whether the incidence of listeriosis in China is underestimated. This systematic review of articles on listeriosis in mainland China published during the years 2011–2017 was conducted to determine the clinical and epidemiological characteristics of listeriosis in mainland China since 2010.

Materials and methods

Search strategy and selection criteria

This systematic review was conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (http://www.prisma-statement.org/Default.aspx). A systematic search of three Chinese language databases (Wanfang Data Knowledge Service Platform (Wanfang), China National Knowledge Infrastructure (CNKI), and SinoMed) and three English language databases (PubMed, Cochrane Library, and Embase) was performed to identify articles published between January 1, 2011 and October 12, 2017. The full search strategy is shown in the **Supplementary Material** (Appendix).

Original articles were obtained and assessed in detail for their inclusion in this review. Articles had to meet the following criteria for inclusion: (1) the cases or isolated Listeria were from mainland China; (2) the articles reported listeriosis or Listeria isolates from clinical patients, or studied the distribution of listeriosis among other diseases. Articles that did not study listeriosis or Listeria isolated from clinical patients or that reported patients not from mainland China were excluded. Reviews and theses were also excluded.

Data extraction

The following information, where provided, was extracted from the articles on clinical listeriosis or case reports: first author, title, journal, year of publication, city, number of patients, year of onset, month of onset, sex, age, underlying diseases, clinical manifestations, positive samples, treatments, and outcomes. For articles on the percentage of listeriosis among other diseases, information on the type of disease, total patient number, number of patients with listeriosis, and the positive samples was extracted. For articles that investigated Listeria isolates, the serotype and multilocus sequence typing (MLST) data of the isolates were extracted.

Study definitions

A listeriosis patient was defined as a patient from whom Listeria was isolated and who was reported to have fever, diarrhea, headache, or other clinical manifestations that corresponded to listeriosis. Non-perinatal patients were defined as those who were not pregnant women or newborns. If the patient was either a pregnant woman or a newborn, they were considered a perinatal patient. The mother and all her newborns and/or fetuses were counted as one instance.

According to the clinical manifestations, a listerial central nervous system (CNS) infection was defined in the case that Listeria was isolated from a patient's cerebrospinal fluid (CSF) or when a patient had neurological symptoms (altered consciousness, seizures, nuchal rigidity, or focal neurological symptoms, and an increased white blood cell count in the CSF) and a positive blood culture revealed Listeria. If the patient did not meet the criteria for a diagnosis of CNS infection but Listeria was isolated from the blood, this patient was considered to have bacteremia. A focal infection was defined in the case that Listeria was isolated from pus or biopsy tissue from a site of focal infection, without clinical manifestations suggesting a systemic infection cause and a positive blood/CSF culture revealing Listeria.

When the outcome was death for a non-perinatal patient or abortion or newborn death for a perinatal patient, this was counted as an adverse outcome. An infection was considered to be healthcare-associated when the patient manifested the onset of listeriosis symptoms at more than 48 h after admission for medical conditions related to other diseases.

Statistical analysis

Descriptive methods were used in the study; measurement data with a normal distribution are described as the mean ± standard deviation (SD). Significant differences between two independent samples were determined with the independent samples *t*-test, while count data were analyzed by Chi-square test. A p-value of <0.05 was recognized as statistically significant.

Results

Listeriosis in mainland China

A total of 3503 articles were identified (Figure 1). Among these, 1884 unique articles remained after the removal of 1619 duplicate articles according to the title, authors, journal, and publication date. Following reading of the titles and abstracts, 1702 articles were excluded: 685 were on non-human listeriosis or Listeria isolates, 325 reported the method of testing for the bacteria, 56 were investigations of a Listeria vaccine, 168 were on the antimicrobial activities of different substances, 18 reported the method of subtyping Listeria, 185 were on the microbiological characteristics of Listeria, 180 concerned immunology and other basic research and not clinical listeriosis or Listeria isolates, 27 were reviews, and another 55 did not describe listeriosis in mainland China. The eligibility of the remaining 182 full-text articles was assessed. Among these, 12 were theses, 16 did not describe clinical listeriosis or Listeria isolates, and 18 described the same patients, as identified by the patient information and/or by contacting the authors. Thus, 136 articles met the inclusion criteria, and the relevant data were extracted.

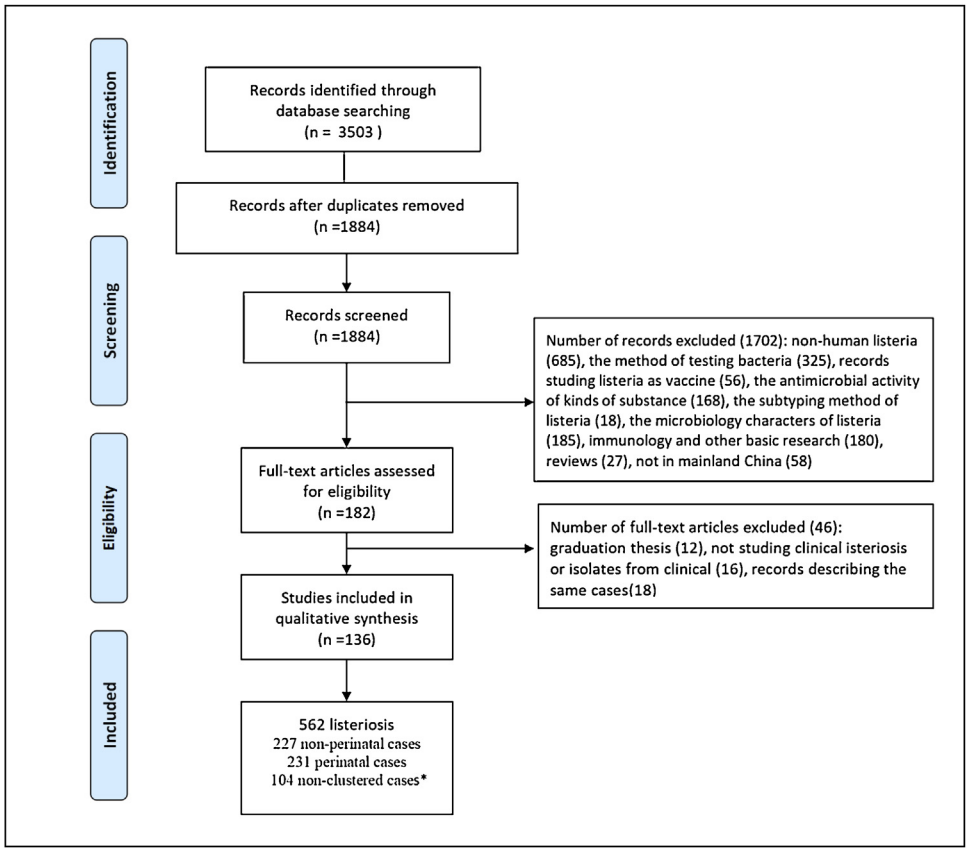


Figure 1. Flowchart of the search strategy. *When there was not adequate clinical information to define the patients as perinatal or non-perinatal, the patients were described as non-clustered.

In total, 562 listeriosis patients were reported from January 2011 to October 2017, including 227 non-perinatal patients, 231 perinatal patients, and 104 non-clustered patients in whom the clinical diagnosis was diarrhea without a description of the other characteristics of the patients. With the exception of one record reporting a man infected by *Listeria ivanovii* (Li et al., 2012), all other patients were infected by *L. monocytogenes*. In total, 106 adverse outcomes were reported among the 368 patients with known outcomes (28.80%).

The number of records and patients reported in each year and each month are shown in Figure 2A and B, respectively; the accurate year of onset was available for 178 patients and the accurate month of onset for 99 patients. The number of patients increased each year until 2013 and then decreased each year, reaching 0 patients in 2017. Although patients were reported in each month, most patients were reported in the summer months. The geographical distribution of the reported listeriosis patients among the different provinces is shown in Figure 2C. The capital city, Peking, reported the most patients.

Non-perinatal patients

There were 227 non-perinatal patients with listeriosis, among the 164 patients having gender information, 52.4% (86/164) of whom were male. Details of the non-perinatal patients are shown in Figure 3. Age information was available for 113 patients and patients older than 55 years accounted for 32.74%. The empirical antibiotic used was mostly a cephalosporin, while penicillin tended to be the most commonly used antibiotic after diagnosis, with a cephalosporin used in a few patients. Steroids were used in 14 patients before diagnosis and in nine patients after diagnosis. The clinical manifestations were non-specific. In total, 159 of the 162 patients with body temperature data had a fever and more than half of these patients had a high fever (51.23%).

Among the 163 patients with a known medical history, 110 had an underlying disease (UD), including 49 with autoimmune diseases, 29 with malignancies, nine with diabetes, five with renal failure, six with cardiopathies, 12 with hepatitis/hepatocirrhosis, two with tuberculosis, and one with an HIV infection. These patients with UD were compared to patients without an underlying disease (non-UD) (Table 1). The age of the UD patients was older than that of the non-UD patients ($p = 0.001$), while the non-UD patients were more likely to have bacteremia and CNS infections than the UD patients ($p < 0.001$). The infection types and positive samples were more diverse for UD patients than for non-UD patients.

Perinatal patients

There were 231 perinatal listeriosis patients, among whom 27 were described in studies reporting the percentage of patients with listeriosis among those with other diseases. Approximately 70.27% (130/185) of perinatal listeriosis infections occurred before 37 weeks of gestation. In total, 199 single pregnancies and five twin pregnancies were described (Figure 4), with 186 newborns and 23 aborted fetuses. Forty-seven newborns died and 138 survived, with three normal newborns; the outcome was not reported for one newborn. The positive samples cultured in perinatal patients are shown in Figure 4B; 150 of 159 neonatal blood culture results were positive, while only 48 positive maternal blood cultures were recorded. The most common maternal clinical manifestation was prenatal fever, followed by meconium-stained amniotic fluid

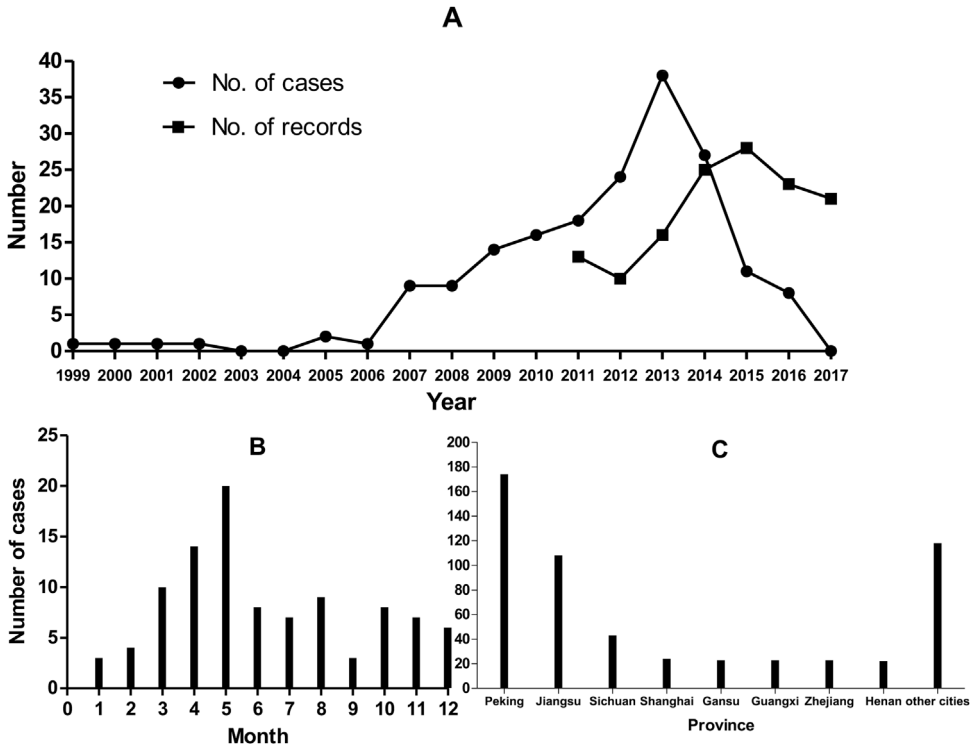
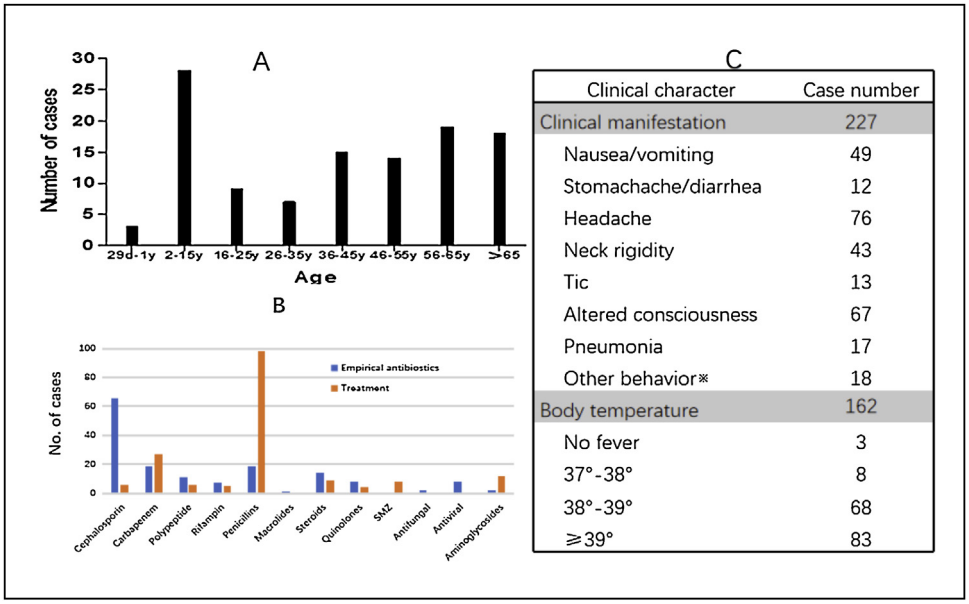


Figure 2. Distribution of listeriosis cases in mainland China. (A) Number of patients and articles reported over the study years. (B) Number of patients according to the month of onset. (C) Geographical distribution of patients among the cities of China.

(MSAF) and fetal distress, while among neonatal patients, bacteremia was the most common clinical manifestation, followed by CNS infection and pneumonia. Similar to the non-perinatal patients, the most common antibiotic used in neonatal patients with listeriosis was a cephalosporin before diagnosis and penicillin after diagnosis.

Distribution of listeriosis reported among other diseases

Twenty-five articles reporting 220 listeriosis patients described the percentage of listeriosis among other diseases. The distribution of listeriosis among other diseases is shown in Table 2. Most listeriosis was reported in non-perinatal pneumonia (18.75%),



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Clinical character	Case number
Clinical manifestation	227
Nausea/vomiting	49
Stomachache/diarrhea	12
Headache	76
Neck rigidity	43
Tic	13
Altered consciousness	67
Pneumonia	17
Other behavior※	18
Body temperature	162
No fever	3
37°-38°	8
38°-39°	68
⩾39°	83

Figure 3. Details of 227 non-perinatal listeriosis patients. (A) Age distribution of the non-perinatal listeriosis patients. (B) Drugs used before and after the diagnosis of non-perinatal listeriosis (SMZ: sulfamethoxazole). (C) Clinical manifestations among non-perinatal patients (※Peritonitis $n = 2$; bloating $n = 5$; gastrointestinal bleeding $n = 2$; facioplegia $n = 1$; chills $n = 1$; ankle swelling $n = 1$; cough $n = 2$; epilepsy $n = 1$; numbness $n = 1$; facioplegia and gastrointestinal bleeding $n = 1$; rash and conjunctival hyperemia $n = 1$).

Table 1
Clinical characteristics of non-perinatal patients.

Characteristics	Underlying disease (UD)		All	*p*-Value
	Yes	No		
Number of patients	110	53	164	–
Age (years), mean ± SD	51.42 ± 20.51	33.86 ± 23.49	45.44 ± 23.02	0.001
CNS infection, *n*/*N*	41/67	47/49	118/164	<0.001
Bacteremia, *n*/*N*	45/57	36/38	119/142	<0.001
Focal infection, *n*	6	0	6	–
CSF culture-positive, *n*/*N*	21/35	39/46	87/109	–
Blood culture-positive, *n*/*N*	45/57	47/53	119/159	–
Other samples, *n*	11	1	12[a]	–
Sequelae, *n*	4	12	16[b]	–
Died, *n* (%)	30.91% (34/110)	9.43% (5/53)	23.78% (39/164)	0.03

CSF, cerebrospinal fluid; CNS, central nervous system; SD, standard deviation.
[a] Ascites (*n* = 6), drainage of cerebral abscess (*n* = 1), wound exudate (*n* = 1), bone marrow puncture tissue (*n* = 2), pulmonary puncture tissue (*n* = 1), peritoneal dialysis fluid (*n* = 1).
[b] Vocal cord paralysis (*n* = 1), facioplegia (*n* = 1), dyskinesia (*n* = 3), epilepsy (*n* = 1), mental retardation (*n* = 1), limited eye abduction (*n* = 1), moderate disability (*n* = 1), reduced movement of the limbs (*n* = 2), cerebellar softening range (*n* = 1), incontinence (*n* = 1), hydrocephalus (*n* = 1), mental abnormalities (*n* = 1), hydrocephalus (*n* = 1).

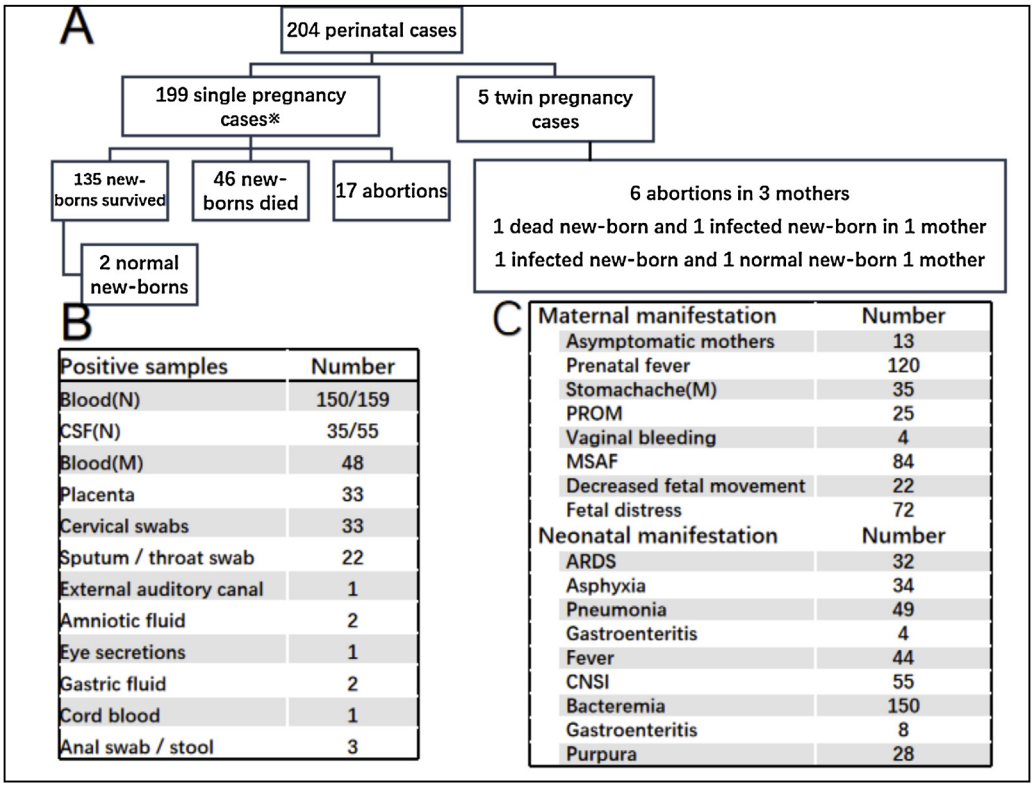
followed by neonatal meningitis (13.04%) and intrauterine infection (9.30%).

Reported possible sources of Listeria infection

The perinatal patients reported were almost all suffering from community-acquired infections. Among the 154 non-perinatal patients with data for the onset time, 51 patients with listeriosis (33.12%) had healthcare-associated infections. Only 17 patients were reported as having consumed a diet of raw/cold food or unclean food, mostly barbecue. In three patients, beef and manufactured meat sold in the supermarket were traced as the sources of contamination by pulsed field gel electrophoresis (PFGE) (Hou et al., 2015; Wang and Chen, 2016; Guo et al., 2015).

Characteristics of isolates

Serotype data were available for 87 clinical Listeria isolates and MLST data for 43 clinical Listeria isolates. The most commonly reported serotype was 1/2b (38/87, 43.68%), followed by 1/2a (24/87, 27.59%), while 13 MLST subtypes were reported, namely, ST87, ST3, ST7, ST8, ST1, ST5, ST2, ST9, ST121, ST155, ST378, ST381, and ST778. The most commonly isolated subtype was ST87 (12/43, 27.91%).



Positive samples	Number
Blood(N)	150/159
CSF(N)	35/55
Blood(M)	48
Placenta	33
Cervical swabs	33
Sputum / throat swab	22
External auditory canal	1
Amniotic fluid	2
Eye secretions	1
Gastric fluid	2
Cord blood	1
Anal swab / stool	3

Maternal manifestation	Number
Asymptomatic mothers	13
Prenatal fever	120
Stomachache(M)	35
PROM	25
Vaginal bleeding	4
MSAF	84
Decreased fetal movement	22
Fetal distress	72
Neonatal manifestation	**Number**
ARDS	32
Asphyxia	34
Pneumonia	49
Gastroenteritis	4
Fever	44
CNSI	55
Bacteremia	150
Gastroenteritis	8
Purpura	28

Figure 4. Clinical presentation of perinatal listeriosis patients. (A) Clinical outcomes of 204 perinatal patients (※the outcome of one newborn was unknown). (B) Positive samples reported in 204 perinatal patients (N, neonatal; M, maternal). (C) Clinical manifestations of maternal and neonatal listeriosis among 204 patients (PROM: premature rupture of the membranes; ARDS: acute respiratory distress syndrome).

Table 2
Distribution of listeriosis among other diseases.

Characteristics of study populations	Number of articles	Number of patients	Number of patients with listeriosis	Percentage (%)	Positive samples
Pneumonia in elderly	1	112	21	18.75	Sputum
Neonatal purulent meningitis	3	23	3	13.04	Blood/CSF
Intrauterine infection	1	86	8	9.30	–
Diarrhea	2	1537	104	6.77	Feces
SLE	1	16	1	6.25	Blood
New-born septicemia	4	448	27	6.03	Blood
Non-perinatal purulent meningitis[a]	7	562	27	4.80	CSF/blood
Neonatal pneumonia	1	51	2	3.92	Blood
Bacteremia in hemopathy	2	223	6	2.69	Blood
Bacterial vaginosis	1	732	16	2.19	Vaginal secretions
Neonatal intrauterine infection	1	51	1	1.96	–
Prenatal fever	1	11795	4	0.03	Blood (M/N)

CSF, cerebrospinal fluid; M/N, maternal/neonatal; SLE, systemic lupus erythematosus.
[a] Only 347 patients were reported to have positive cultures.

The serotypes of eight *L. monocytogenes* isolates from perinatal patients were 1/2b ($n = 3$), 1/2a ($n = 4$), and 4b ($n = 1$); two from non-UD patients were 1/2a and 4b, and one isolated from a UD patient was 1/2a. The serotypes of 38 *L. monocytogenes* isolates obtained from blood samples were 1/2b ($n = 21$, 55.26%), 1/2a ($n = 13$, 34.21%), 1/2c ($n = 2$, 5.26%), 3a ($n = 1$, 2.63%), and 4b ($n = 1$, 2.63%). The serotypes of 13 isolates obtained from CSF were 1/2b ($n = 5$, 38.46%), 1/2a ($n = 6$, 46.15%), 4b ($n = 2$, 15.38%). The serotypes of 13 isolates obtained from placenta were 1/2b ($n = 9$, 69.23%), 1/2a ($n = 2$, 15.38%), 4b ($n = 2$, 15.38%). The serotype of one isolate obtained from pleural fluid was 1/2b.

The MLST results for five *L. monocytogenes* isolates from perinatal patients were ST1 ($n = 1$), ST3 ($n = 2$), ST87 ($n = 1$), and ST778 ($n = 1$); two isolates, one from a UD patient and one from a non-UD patient, were ST8. The MLST results of 20 *L. monocytogenes* isolates obtained from blood samples were ST3 ($n = 2$, 10.00%), ST5 ($n = 2$, 10.00%), ST7 ($n = 4$, 20.00%), ST8 ($n = 3$, 15.00%), ST9 ($n = 1$, 5.00%), ST87 ($n = 6$, 30.00%), ST155 ($n = 1$, 5.00%), and ST778 ($n = 1$, 5.00%); four isolates obtained from CSF were ST2, ST8, ST87, and ST381 and three isolates obtained from the placenta were ST87 ($n = 2$) and ST1 ($n = 1$).

Discussion

The present study and that of Feng et al. (2013) report listeriosis in mainland China; however, the cases in the present study were reported during the years 2011–2017, while those in the study of Feng et al. were reported during the years 1964–2010 (562 vs. 229), and more UD patients were reported in the present study (110/163 vs. 49/70). Similarly, an increase in the number of patients with listeriosis in Korea has also been reported over the past 10 years (Choi et al., 2018), with the elderly and the immunocompromised as the patients most involved. Improvements in methods of tracing Listeria infections (Moura et al., 2016; Jackson et al., 2016), increased awareness of listeriosis among clinicians, and the greater number of databases searched in the present study may have contributed to this increase in number of cases; however, it is speculated that the number of cases of listeriosis in mainland China may have been underestimated previously. The serious clinical manifestations and high mortality of listeriosis may have resulted in missed or incorrect diagnoses in past decades, which may also have contributed to an underestimation of the number of patients with listeriosis in the past (Kylat et al., 2016; Zolin et al., 2017). Further research is needed to prove this. However, it was not possible to obtain an accurate incidence rate or estimation of the disease burden of listeriosis in China because of the study design.

Similar to other reports (Radoshevich and Cossart, 2018; Salama et al., 2018; Charlier et al., 2017; Pucci et al., 2018), listeriosis patients in China could be categorized into perinatal, UD, and non-UD patients according to their characteristics. Listeria infection shows no specific clinical manifestations, and both syndromes and positive samples were diverse among patients, with fever being the most common symptom (Charlier et al., 2017). In addition to bacteremia and CNS infection, Listeria can also lead to focal infections such as pneumonia, enteritis, and ophthalmitis (Marsaudon et al., 2018; Wan and Dong, 2015; Zhu et al., 2012). In the present study, the average age of non-UD patients was relatively younger than has been reported in other countries (Charlier et al., 2017; Choi et al., 2018). The reason for this may be that elderly people in China prefer to eat well-cooked food rather than raw or half-raw food. In addition, among non-perinatal patients, the mean age of the non-UD patients was younger than that of the UD patients ($p = 0.001$), and both UD and non-UD patients developed bacteremia and/or CNS infections, with the exclusion of a few focal infection patients in the UD group. However, some researchers have indicated that invasive infections such as bacteremia and CNS infections are more likely to occur in patients with a poor immune status (McCollum et al., 2013). As the clinical data collected for this study were not complete, conclusions cannot be drawn about whether there is a relationship between immunity and invasive Listeria infection, and future studies are required. There is agreement that the mortality rate of immunocompromised patients is higher than that of immunocompetent patients, and most listeriosis patients are immunocompromised (Wang et al., 2013; Charlier et al., 2017; Arslan et al., 2015).

Perinatal listeriosis accounted for more than 50% of the total infections in this study, which is a much higher proportion than those reported in other countries (Pucci et al., 2018). Perinatal listeriosis mostly occurred before 37 weeks of gestation, and the adverse event rate was higher than in non-perinatal listeriosis (Pucci et al., 2018); thus, it is recommended that empirical antibiotics be used to treat perinatal infections, even when the maternal blood culture is negative (Charlier et al., 2017). However, Veesenmeyer and Edmondson, among others, do not recommend the use of ampicillin as empirical treatment for newborn infections after the first week of life because of the low morbidity of listeriosis and high level of antimicrobial resistance of Gram-negative bacteria (Veesenmeyer and Edmonson, 2016); therefore, it is important to diagnose and treat perinatal listeriosis early. As not all samples from listeriosis patients are positive (Mansbridge et al., 2017), contributing to a delay in diagnosis of listeriosis, it is advisable to culture multiple types of sample for listeriosis initially (Awofisayo-Okuyelu et al., 2016).

A French national cohort study (Charlier et al., 2017) showed that the use of active β-lactam and aminoglycoside antibiotics

was positively correlated with survival, while for CNS infection, dexamethasone contributed to a higher mortality rate. A delay in the initiation of antibiotic therapy has been found to be a risk factor for CNS infection, and starting antibiotics earlier has been inversely related to CNS infection and high mortality rates (Arslan et al., 2015; Maertens De Noordhout et al., 2016; Hong and Yang, 2012). As there are no treatment guidelines for listeriosis in mainland China, the antibiotics used vary; this may be correlated with the high mortality rate of listeriosis. Hence guidelines for the diagnosis and treatment of listeriosis are urgently needed in China.

Peking and the coastal areas of China reported the greatest numbers of listeriosis patients, which may be due to the higher detection rate of Listeria, dietary habits, and high population density in these areas. The contamination of seafood by *L. monocytogenes* has been reported in many studies (Leong et al., 2015; Vongkamjan et al., 2017), which may also be related to the higher number of listeriosis patients in coastal areas. In addition, more patients were reported during the summer. Contaminated ice cream, fruit, and other cold foods (Ottesen et al., 2016) have been reported to cause listeriosis during hot weather, which may be related to the pattern of Listeria infection in China. However, the related data were not comprehensive, and the reported patients may not represent the true situation of listeriosis in mainland China; thus, definitive conclusions cannot be drawn.

All 562 listeriosis patients reported in this research had sporadic infections, without evidence of an outbreak. Healthcare-associated listeriosis infections accounted for 33.12% of infections in non-perinatal patients in this study, and 44% were reported in a tertiary hospital in Peking (Wang et al., 2013). High rates of healthcare-associated listeriosis have also been reported in other countries (Maertens De Noordhout et al., 2016; Mazengia et al., 2017). From 1999 to 2010, one listeriosis outbreak involving 82 patients aged between 8 and 12 years was reported in mainland China; this was caused by the contamination of meals at an elementary school (Feng et al., 2013). In the present study, only three suspected patients were reported as outbreak patients, without solid supporting laboratory data. However, the total patient number increased continuously until 2013, after which it decreased continuously until it reached 0 in 2017, which may indicate an unidentified outbreak. Therefore, a comprehensive monitoring system for Listeria infection is urgently needed in China. Healthcare-associated environments and surrounding areas must be given precedence.

Unlike the data reported previously in China, the most frequent serotype isolated from clinical patients in this study was 1/2b (43.68%), followed by 1/2a (27.59%). For MLST, the results of the present study are similar to those of other studies, with ST87 being the most frequent ST in China (Wang et al., 2015); however they are not in agreement with results reported from other countries (Amato et al., 2017). The reasons for the different subtype distributions among different time periods and countries remain unclear. It has been reported that the rate of evolution of Listeria is low (Moura et al., 2016), so whether there is a specific geographical distribution of Listeria and whether import and export play a role in this phenomenon needs further study. However, the number of isolates included in the present study was too small to draw solid conclusions.

This systematic review has some important limitations. First, all of the data collected were retrospective and some analyses could not be performed, such as those involving patient age, clinical manifestations, and pathogenic characteristics of Listeria in mainland China. Second, the patients reported in this study may not include all patients with listeriosis in mainland China, so the number of patients with listeriosis in this study cannot represent the overall epidemiology of listeriosis in China.

Acknowledgements

We thank the authors who responded to our e-mails in a timely manner. All of them answered our questions patiently and tried their best to help us address the questions that arose when we analyzed duplicate patients.

Funding

This work was supported by the National Key Research and Development Program of China (grant number 2017YFC1601503) and the National Key Research and Development Program of China "Study on Precision Medical Ethics, Policy and Regulation Framework" (grant number 2017YFC0910100). The funders had no role in the study design, data collection, data analyses, preparation of the manuscript, or decision to publish.

Ethical approval

Approval was not required.

Conflict of interest

There are no conflicts of interest to report.

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at https://doi.org/10.1016/j.ijid.2019.01.007.

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